SCIENTIFIC AGRICULTURE

Vol. XVII NOVEMBER, 1936 No. 3

COLD STORAGE PROBLEMS WITH APPLES[1]

M. B. DAVIS AND D. S. BLAIR[2]

Central Experimental Farm, Ottawa, Ont.

The preservation of apples by cold storage is a problem of increasing economic importance. Like many practices employed to solve a problem, it in itself has introduced a host of difficulties which can only be solved by intensive investigation.

It is unfortunate that while experimental work of a more or less empirical nature is producing information of value, much is still shrouded in mystery and will remain so until a more detailed explanation of the life processes of the fruit is available. The longevity of life of different samples of fruit, aside from varietal differences, is dependent upon the interaction of several factors, among which may be enumerated: nutrition; maturity at time of harvest; time of placing in store; temperature of the storage; humidity; and composition of the atmosphere in the storage.

During the past four years considerable attention has been paid by the Experimental Farms System to a study of the behaviour of apples under cold storage conditions, including a study of apples grown under different cultural and nutritional conditions; picked at different dates; stored at different periods; held at different temperatures; and stored under atmospheres of different composition.

INFLUENCE OF MATURITY ON THE KEEPING QUALITY OF FAMEUSE AND McINTOSH

As will be developed under various headings, maturity plays an important rôle in the keeping behaviour of apples. It is pertinent at this point, however, to refer to various indices of maturity which have been developed. Among these are: the ground colour test; seed coat colour; pressure test; iodine starch test; and refractometer test.

With Fameuse and McIntosh apples the two most useful tests have been the ground colour test and the iodine starch test.

A colour chart has been developed for use in connection with the ground colour test, and Figure 1 gives illustrations for employment in connection with the iodine test.

Little correlation of value has come from the use of the pressure test, while the results from the refractometer test have correlated reasonably well with the ground colour and iodine test but have not added anything to these to warrant its use in their stead.

[1] Contribution No. 467 from the Division of Horticulture, Dominion Experimental Farms System. Read before the Horticultural Group of the C.S.T.A. at the University of New Brunswick, Fredericton, N.B., July 14–15, 1936.

[2] Dominion Horticulturist, and Assistant Horticulturist, respectively.

Without going into the details of all of these examples a minute account of the results obtained by the use of the iodine test will suffice.

If apples are cut equatorially and immersed in a weak potassium iodide-iodine solution the presence of starch may be noticed by the blue coloration. The last tissues to lose their starch are those adjacent to the extremities of the vasculars. In Figure 1 is shown the stages of maturity encountered in various picking date tests, with the exception of a solid starch reaction in very immature fruit.

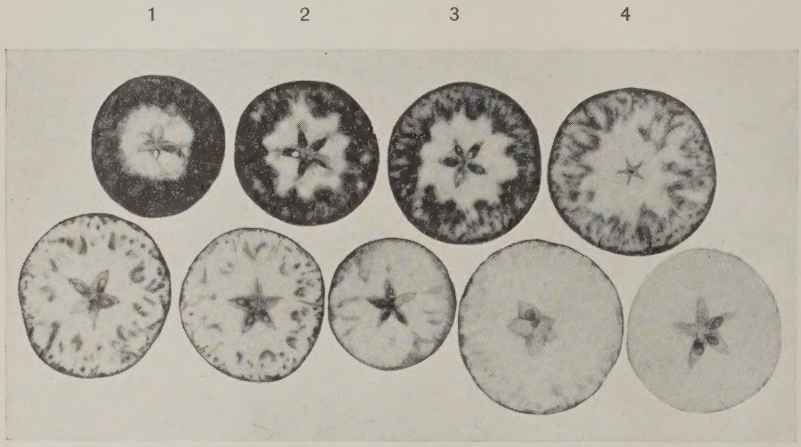

FIGURE 1. Showing amount of starch present in apples at different stages of maturity. The Nos. 1, 2, 3, etc. are referred to in the text.

It has been found as a result of three years' work that McIntosh and Fameuse apples appear to differ somewhat in respect to correlation between starch reaction and keeping quality. It seems safe to state that McIntosh which show a starch reaction as indicated by 1, 2, 3, or 4 in Figure 1 are too immature for good keeping regardless of their nutritional treatment, while McIntosh picked in stages 6 to 8 may or may not keep satisfactorily depending upon their nutritional conditions. Fameuse picked in stages 1 and 2 are too immature for satisfactory keep but if picked in stages 3, 4 or 5 may or may not keep, depending upon their nutritional treatment and storage temperature. It is thus obvious that maturity tests have their limitations but are useful as indicators of immaturity and overmaturity beyond which we should not go. There are differences in keeping quality which cannot be correlated with maturity and which, while not yet fully explained, appear to be due to nutritional causes affecting something more than disappearance of starch and sugar accumulation.

TYPE OF COLD STORAGE SPOILAGE

The types of spoilage incurred under cold storage may be classed under four headings;

1. Loss from rots or fungal invasion,
2. Loss from shrinkage or shrivelling,

3. Loss from apple scald,
4. Loss from physiological decay.

Loss from Rots or Fungal Invasions

Loss from this trouble may be largely controlled or eliminated by careful handling since in most cases fungal invasion takes place at stem punctures, points of bruises or where stems have been pulled out.

Mr. H. N. Racicot of the Division of Botany has been responsible for the identification and classification of the various types of rots affecting McIntosh and Fameuse at Ottawa and his findings are of special interest when correlated with temperature and nutritional treatment. He found four main types as set forth in Table 1.

TABLE 1

Type	Total no. rots	Percentage rots
I. (Penicillium spp.)	1084	61.87
II. (Alternaria spp.)	471	26.88
III. (Botrytis spp.)	150	8.56
IV. (Mucor spp.)	32	1 83
Undetermined	15	86
Total	1752	

Influence of Storage Temperature on Rot Development

Rot development is markedly correlated with storage temperature. The percentage of rots developing at each temperature is about as follows:

30° F. — 2.03%
32° F. — 3.33%
36° F. — 6.35%
40° F. — 10.79%

It will be seen that at the lower temperatures total loss from rots is almost a negligible amount.

The effect of temperature on the development of types of rots, regardless of variety or origin of material is shown in Table 2 and is of interest. The data are presented on the *total rot basis*. Type I was not as prevalent at the high as at the low temperatures, this being consistent for the three samplings. Type II, on the other hand was greatly suppressed at the low temperatures, while at the 40° F. temperature it was nearly as abundant as Type I. No specimens of *Alternaria* spp. were noted in the 30° F. room until the second sampling 4/3/35. Type II reached its peak of prevalence in the second sampling. Type III, like Type I, develops much more favourably under the low temperatures. In the first sampling month 11/1/35, the *Botrytis* fungus was present to the extent of 14% at 30° F. and only 1% at 40° F. Type IV appeared in small numbers and was present almost entirely on the first and second sampling dates.

In so far as nutrition is concerned it has been noticeable that fruit grown under high nitrogen conditions are more subject to rot than fruit from low nitrogen areas. There is a possibility that this is an indirect effect due to softer fruit which is more readily bruised in handling.

TABLE 2.—EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF TYPES OF ROTS, REGARDLESS OF VARIETY OR ORIGIN OF MATERIAL. PERCENTAGE ON TOTAL ROT BASIS

Temperature	First sampling Types					Second sampling Types					Third sampling Types				
	1	2	3	4	Unidentified	1	2	3	4	Unidentified	1	2	3	4	Unidentified
30° F.	85.71	0.00	14.29	0.00	0.00	69.39	18.37	10.20	2.04	0.00	74.24	10.61	12.12	1.52	1.52
32° F.	91.67	2.08	4.17	2.08	0.00	54.35	32.07	5.98	6.52	1.08	63.36	24.43	12.21	0.00	0.00
36° F.	91.18	5.88	0.00	2.94	0.00	65.52	24.14	6.90	3.44	0.00	70.67	14.42	9.62	0.00	5.29
40° F.	51.28	42.31	1.28	5.13	0.00	45.37	43.06	7.41	4.16	0.00	60.82	29.63	9.36	0.00	0.19
Sum total for all four temperatures	72.46	21.55	2.40	3.49	0.00	53.92	33.96	7.09	4.66	0.37	64.25	24.12	10.30	0.09	1.24

NOTE:—1, 2, 3 and 4 in above table refers to types I, II, III and IV as described in text.

Loss from Shrinkage

Loss from shrinkage is due to two causes, viz., rate of respiration controlled by temperature and atmosphere; and loss by evaporation, transpiration or desiccation controlled by the relative humidity of the store.

At the lower temperatures of 30° and 32° F. loss from this cause is very slight if the relative humidity is maintained at 85 or 90%. At the higher temperature of 40° F. loss from shrinkage is an important factor, and since high relative humidities have failed to control this, it must be assumed that the respiration rate is of primary importance. Control of shrinkage by regulated atmospheres will be referred to later.

Loss from Apple Scald

Some varieties of apples are very prone to scald at low temperatures and for the control of this ill there has been available for some time the now commonly used oil wraps. While McIntosh and Fameuse are not very susceptible to scald, particularly in the cold store, there are occasions when scald develops after removal to higher temperatures whether the fruit is wrapped or not.

Influence of Maturity on Apple Scald

In the case of McIntosh and Fameuse, maturity at time of storage appears to be of more importance than any other single factor. Picking date tests with these varieties have revealed that immaturity is the greatest contributing factor to its development. Table 3 sets forth information in this connection.

TABLE 3

Variety	Picking date	Starch reaction	Average for all temperatures % scald
McIntosh	17/9/34	2–4	17.33
McIntosh	28/9/34	3–5 See Figure 1	7.33
McIntosh	9/10/34	6–8	0.00
Fameuse	17/9/34 Solid starch	−1	31.00
Fameuse	28/9/34	1–2	1.00
Fameuse	9/10/34	3–5	0.00

The above is the amount of scald present on fruit stored at all temperatures after removal from the store. All fruit was wrapped in oiled paper before being placed in the store and scald was not apparent until after removal to a temperature of about 60° F. It is apparent that immaturity at picking time has been responsible for this development.

Influence of Temperature on Scald Development

As a means of control in scald development temperature is important. A general statistical treatment of the effect of temperature on scald development has indicated that 30° and 32° temperatures show a significantly higher percentage development of scald than either 36° or 40° temperatures.

In fact, fruit stored in ordinary atmosphere at 40° has seldom developed scald on removal to a higher temperature. Another factor influencing its development is ventilation or controlled atmospheres and this point will be developed more fully under the heading of gas storage.

Loss from Physiological Decay

By far the greatest loss encountered in cold storage is the loss from physiological decay or breakdown. In Fameuse and McIntosh this takes the form of brownheart or core-flush or in some instances a breakdown of the Jonathan type. As in other forms of loss, several factors contribute to this trouble and these may be considered, in turn, under their respective headings.

Influence of Maturity in Physiological Decay

A statistical treatment of the results from our work with McIntosh and Fameuse has indicated a close correlation between immature McIntosh and premature core-flush development, particularly when stored at temperatures higher than 32° F. In the case of Fameuse, however, at 32° F. there existed little difference between the amount of core-flush development in mature and immature specimens.

Influence of Delayed Storage on Core-Flush Development

The question as to whether delayed storage will increase or decrease core-flush development appears to be closely linked with the climacteric of the respiration curve. While our evidence in this connection is not wholly complete there appears to be a danger in delayed storage of placing the fruit in the store when it is just at its climacteric, which induces rapid core-flush development. Storage previous to the onset of the climacteric or after the climacteric rise does not appear to increase the amount of core-flush development. For practical purposes we advise immediate storage of fruit picked at the proper stage of maturity and would caution against cold storing McIntosh and Fameuse which have been held at higher temperatures for more than forty-eight hours.

Influence of Temperature on Core-Flush Development

The temperature at which the fruit is stored has a profound effect on the development of physiological troubles and as will be developed later there appears to be a correlation between nutrition, storage temperatures and storage atmosphere.

A statistical study of lots of McIntosh and Fameuse stored in 1935, regardless of date of pick, or source or date stored, showed there was a significant difference in favour of 32° F. for Fameuse and 36° or 40° F. for McIntosh. In the case of Fameuse, 32° F. may be said to be capable of ironing out differences in keep due to maturity and other factors. In other words, it would appear to be an ideal temperature for this variety. On the other hand, higher temperatures, such as 36° F. or 40° F. permit the influence of these other factors to play their part so that Fameuse from certain plots or Fameuse at wrong stages of maturity will develop core-flush very rapidly while those from ideal conditions will continue free of this trouble for a long period. With McIntosh the situation is just about reversed. Here, a significant difference was obtained in favour of 36°

and 40° F. as against 30° and 32° F. McIntosh stored at the higher temperatures, regardless of source and pre-storage treatment, remain relatively free of physiological decay as compared with those stored at 32° F. for the same length of time. On the other hand certain lots of McIntosh stored at 32° F. will retain their crispness and quality much longer than any lots at the higher temperatures while still remaining free from core-flush. Since fruit stored at 40° F. tends under ordinary conditions to shrink rapidly and lose that crispness so desirable this temperature cannot be considered as ideal for long periods. The 36° F. temperature, however, more closely approximates the condition of 32° with a greater safety in so far as core-flush development is concerned, and would appear to be a more suitable temperature for McIntosh than 32° unless in the case of known orchards where previous experience has indicated that 32° F. is satisfactory.

Influence of Nutrition on the Development of Core-Flush

The effect of cultural practices or nutrition on the keeping quality of apples has become very apparent in recent years but owing to the almost complete necessity of attempting to seek fundamental information from field conditions where all factors are not under control much difference of opinion has arisen.

Haynes and Archbold (1) concluded that low nitrogen and high sucrose and probably a large amount of cell wall material were conducive to good keeping, especially at low temperatures.

Brown (2) a co-worker of Haynes, attempted to correlate the ash constituents of apples and the soil content with the keeping quality of the fruit. She found an association between good keeping quality and high percentages of potassium and phosphorus in the soils and also in the fruit.

Wallace (3) concluded that the findings of Haynes and Archbold relative to low nitrogen and high sucrose is not of general application, although admitting that a low nitrogen condition induced by grassing down had in all cases prolonged the life of the fruit, both at ordinary temperature and cold storage temperature. Wallace's researches also indicated that the findings of Brown relative to the potash relationships of the fruit cannot be accepted as a general truth. His own results indicated that high potash fruits may be more susceptible to rots than potash deficient fruits and that while samples of high potash fruits may exhibit better keeping qualities at low temperatures than potash deficient fruits the reverse may be true at higher temperatures.

To return to the effect of nitrogen on keeping quality, Haynes and Archbold, as already mentioned, have indicated in favour of low nitrogen for good keeping quality; this has also been actually corroborated by Wallace's grass land experiments. On the other hand, Gourley and Hopkins (4) state that they were unable to find any consistent relation between fertilizer treatment and the amount of decay or physiological breakdown in the orchards they had under study. They particularly point out that no amount of nitrate of soda used induced breakdown of the fruit.

In connection with this question of the influence of nitrogen on keeping quality the work of Kraybill is pertinent. He (5) and other workers, have

shown that the form in which nitrogen exists in the plant depends on the phosphate content. In the presence of an excess of nitrogen over phosphate the nitrogen in the plant will tend to be in water soluble forms, such as amino-acids, amides, etc. The moment the phosphate content is raised this water soluble nitrogen reverts to protein. It would appear from this that the amino-acid content would depend on the phosphate-nitrogen balance.

The findings of Gourlay and Hopkins have been questioned by Du Toit and Reyneke (6) who stress the nitrogen-phosphorus relationship, pointing out that whether or not nitrogenous fertilizers will produce increased respiration will depend on whether the nitrogen is going to exist in the plant as amino-acid or not and this in turn will depend upon the P/N ratio. The relationship between respiration rate and senesence is, of course, fairly well established.

The foregoing brief review of some of the literature available is sufficient to present a fair picture of some of the difficulties surrounding a solution of the effect of nutrition on the keeping quality of apples.

Our own results with fruit from different orchards and fertilizer plots have indicated the influence of nutrition on the keeping quality of apples and tend to confirm the theory of the importance of the P/N ratio.

From a Fameuse orchard, part under sod and part under mulch, where fertilizer experiments were being run interesting data has been accumulated. The application of nitrogen to the sod section actually improved the keeping quality of the fruit at 36° and 40° F. Applications of nitrogen only to the mulched section brought about a significant deterioration in keeping quality. The trees in the sod section bore all the resemblances of a low nitrogen condition where no nitrogen was applied while the application of mulch alone tended to bring about a higher nitrogen condition, judging by foliage symptoms. The application of both nitrogen and phosphorus to the sod section in the amounts employed, viz., 6 lbs. nitrate of soda and 3 lbs. superphosphate per tree, completely destroyed the keeping quality of Fameuse at these temperatures. On the other hand the same combination applied to the mulched section actually brought about improved keeping quality. There is at least an indication here of nitrogen phosphorus relationship. This relationship is also indicated in another series of plots which for three years have given rather consistent results under sod where applications of nitrogen only, up to 9 lbs. per tree, did not produce significant impairment of keeping quality. The combination of 3 lbs. nitrate of soda and 6 lbs. slag, however, produced 100% core-flush as compared to only 8% where 3 lbs. nitrogen alone was employed, whereas a combination of 9 lbs. nitrogen and 6 lbs. slag produced only 12% core-flush. There is distinct evidence here of a relationship between nitrogen and phosphorus in influencing keeping quality.

At the Experimental Station, Kentville, N.S., there are some interesting results from Wagener with breakdown. Two plots received both nitrogen and acid phosphate, but in one case the amount of acid phosphate applied over a 20-year period was double that of the other. The plot receiving the smaller amount of phosphorus produced 6.3% breakdown as compared to 22.1% from the plot receiving double the amount of phosphorus.

The ill effects of excess nitrogen applications alone have been found in British Columbia, Quebec and Nova Scotia, and from the long time fertilizer experiments at Kentville, N.S., there is abundant evidence of the value of nutritional balance in maintaining keeping quality; complete fertilizers of about the order of 9-5-7 having produced more satisfactory results than single or two element applications over a long period of time.

THE ADVENT OF GAS STORAGE

As has already been pointed out, 32° F. cannot be considered as an entirely satisfactory temperature for McIntosh under all conditions. On the other hand, aside from shrinkage the higher temperatures of 36° and 40° have generally proved superior. If the shrinkage due to increased respiration at the higher temperatures could be overcome there would be a possibility of employing these higher temperatures in a more satisfactory manner.

During the last two years gas storage experiments have been conducted at Ottawa which have indicated possibilities in the use of controlled atmospheres.

McIntosh apples stored at 40° F. under 7.5% CO_2 concentration, provided they are wrapped in oiled paper, have repeatedly kept with the minimum of spoilage and with less shrinkage and loss of flavour and crispness than when kept at 32° F. In fact, apples taken from the gas store as late as March 15th were equally as good as McIntosh normally are on December 1st, with the added advantage that on removal from gas storage to higher temperatures the fruit keeps much better than fruit from ordinary cold storage. It would appear, therefore, that for this variety the employment of gas storage or controlled atmospheres in combination with temperatures higher than 32° F. can not only increase the storage period but actually remove some of the hazard from the cold storing of this variety.

McIntosh apples destined for gas storage should be oil wrapped. Since ventilation is, of course, very limited prolonged exposure to these conditions induces scald development on apples which under ordinary conditions would not scald. Our experience has been that fruit stored under 7½% CO_2 at 40° F. temperature for about two months does not show scald upon removal from the gas store but that if stored for a longer period scald development begins to occur until after a five month period practically all unwrapped fruit develops the trouble in the store, which becomes more noticeable following removal to higher temperatures. Oil wrapped McIntosh apples stored in the above atmosphere and temperature have never developed scald either within the store or upon removal from the store.

REFERENCES

1. Haynes, D. and Archbold, H. K. Chemical studies in the physiology of apples. X. A quantitative study in chemical changes in stored apples. Annals of Botany, 42 : 965. 1928.

2. Brown, J. W. Chemical studies in the physiology of apples. II. The relation between the mineral constituents of apples and the soils on which they are grown. Ann. Bot. 43 : 817. 1929.

3. Wallace, T. Factors influencing the storage quality of fruits. Proc. 1st Imp. Hort. Conf., Part 3, p. 9. 1930.

4. Gourlay, J. H. and Hopkins, E. F. Nitrate fertilization and keeping quality of apple fruits. Chemical, Physiological and Storage Studies. Ohio Agr. Expt. Station Bul. 479 : 1-66. 1931.

5. Kraybill, H. R. Plant metabolism studies as an aid in determining fertilizer requirements. Jour. Ind. & Eng. Chem. 22 : 3, March. 1930.

6. Du Toit, M. S. and Reyneke, J. Studies in the keeping qualities of fruit. Dept. of Agr., Union of South Africa, Science Bul. 118. 1933.

Résumé

Problèmes de la conservation des pommes au froid. M. B. Davis et D. S. Blair, ferme expérimentale centrale, Ottawa, Ont.

Cette étude porte sur la conservation des pommes MacIntosh et Fameuse à des températures réglées, variant de 32° F. à 40° F., ainsi qu'à des atmosphères réglées à la température la plus haute. Les auteurs discutent les applications et les limitations des cartes de couleurs et de l'essai d'iode comme indices de maturité. Ils font ressortir l'effet de la température sur le développement de la pourriture. Le développement de la pourriture physiologique indique que les pommes Fameuse et MacIntosh se comportent de façon quelque peu différente; une température de 32° F. paraît être plus généralement satisfaisante pour la Fameuse que pour la MacIntosh. tandis que les températures plus élevées sont plus pratiques pour cette dernière variété. La perte de poids qui se produit à 40° F. interdit l'emploi prolongé de cette température, mais lorsque cette température était employée avec $7\frac{1}{2}\%$ de CO_2, les MacIntosh sont restées en bon état pendant de longues périodes d'entreposage et ont mieux conservé leur qualité au sortir de l'entrepôt que les fruits entreposés à une atmosphère ordinaire de 32° F. La Fameuse qui, normalement, se conserve bien à 32° F. ne s'est pas bien trouvée jusqu'ici de l'emploi du gaz dans l'entrepôt.

La conservation des pommes paraît se ressentir des engrais employés dans le verger, et des preuves sont apportées à l'appui de l'importance d'un bon équilibre d'azote et de phosphore.

PROGRESS REPORT ON THE INVESTIGATION OF CORKY CORE OF APPLES[1]

L. C. Young and C. F. Bailey[2]
Dominion Experimental Station, Fredericton, N.B.

A physiological disorder of apples, termed corky core, has been present in isolated trees in the Gagetown district for approximately ten years. This condition is characterized by the presence of small, brown, corky areas in the flesh of the fruit. It varies considerably in form according to variety. In the variety Fameuse, in severe cases the fruit is badly deformed, whereas in the variety McIntosh no external evidence of the disorder has ever been noted.

In 1933, a serious outbreak of corky core occurred in several orchards in this district. As a result, a preliminary survey of the situation was made in the fall of the same year. In 1934, a more extensive survey was undertaken with the view of determining the occurrence of this trouble as well as the occurrence of any foliage symptoms suspected as being due to a nutritional disorder.

Inasmuch as corky core existed in orchards receiving a wide range of fertilizer treatments, it was felt that in this area at least, the most profitable line of attack would be an investigation of soil and root conditions and a study of the effect of a few of the rarer elements.

Treatments in 1934

The rarer elements employed were confined to two, namely boron and magnesium, since these two elements had been proven to be connected with deficiency disorders in other crops in New Brunswick. The methods of application used were as follows:

(a) *Wet injections:-* The element in solution in non-toxic concentration is injected directly into the branch, thus reaching the fruit and foliage quickly. The method employed, differed only in minor details to that followed by Roach (3) at East Malling.

(b) *Spraying:* The element in suitable concentration is sprayed directly on the leaves.

In all experiments, the branch and not the tree, was taken as the unit of experimentation. A number of branches were treated, but unfortunately, owing to a misunderstanding between the Station and the owner of the orchard in which the investigation was being conducted, the apples were picked, prior to the readings being taken. Complete records on two small Fameuse trees and partial records on one McIntosh tree only are available. These data are presented in Table 1.

Trees 35 and 90 Fameuse were young trees, bearing light crops of apples, and every apple was examined for the presence of corky core on October 3. On tree 35, 17% of the apples on the check branches were affected with corky core as compared with 33% on the branch sprayed on

[1] Contribution from the Division of Horticulture, Experimental Farms System. Read before the Horticultural Group of the C.S.T.A. at the University of New Brunswick, Fredericton, N.B., July 14–15, 1936.

[2] Assistant in Horticulture, and Superintendent, respectively.

TABLE 1.—RESULTS OF 1934 CORKY CORE INVESTIGATIONS

Tree no.	Variety	Branch no.	Treatment	Concentration	Date of treatment	Percentage Corky Core					Remarks
						Sl.	Med.	Sev.	Total	No. apples examined	
35	Fameuse		Check	—	—	11	6	0	17	18	Entire crop
		1	Magnesium Sulphate Spray	0.25% Mg.	Sept. 5	33	0	0	33	6	Entire crop
		2	Borax Spray	.0125% B.	Sept. 5	0	0	0	0	9	Entire crop
90	Fameuse		Check	—	—	13	0	44	57	45	Entire crop
		1	Magnesium Sulphate Spray	.25% Mg.	Sept. 5	71	0	0	71	17	Entire crop
44	McIntosh		Check	—	—	8	0	0	8	13	This tree picked prior to examination. Only 13 apples remaining on date of examination, Oct. 3.
			Borax—wet injection	.125% B.	Sept. 5	0	0	0	0	12	This branch severely injured and apples dropped prematurely.

September 5 with a magnesium-sulphate solution containing 0.25% magnesium, and 0.0% on the branch sprayed with a borax solution containing 0.0125% boron.

On tree No. 90 Fameuse, spraying with magnesium sulphate effected no measure of control, 57% of the apples from the check branches being affected with cork as compared with 71% on the sprayed branch.

A branch on tree No. 44 McIntosh, receiving an injection of a borax solution containing 0.125% boron was injured rather severely, causing the apples to drop prematurely. The apples on the treated branch were entirely free of cork, whereas 8% of the check apples were affected with cork.

These results at best can only be regarded as being merely suggestive of a possible beneficial effect in the control of cork resulting from the application of boron, either in the form of a spray or as a wet injection. Moreover, the application of magnesium in the form of a spray indicated an entire lack of control.

Treatments in 1935

Three minor elements, boron, magnesium and zinc were used in the 1935 investigations. Methods of application included the wet injections and spraying methods, as practised in 1934, but in addition, a number of dry injections were also made. In the dry injections, the salt was diluted with a definite amount of cane sugar, and the resulting dry mixture filled into $\frac{3}{8}$" holes, bored at intervals around the branch. As in 1934, the branch and not the tree was the unit of experimentation.

Some 35 trees in 7 different orchards were used in these experiments. Unfortunately, approximately one-half of these trees, most of which were known to be affected with cork in 1934, failed to develop cork in 1935. The results on the remaining 17 trees are given in Table 2, which may be briefly summarized as follows:

Magnesium sulphate dry injections:—7 branches treated, complete control in one (tree no. 93), considerable reduction in percentage corky core (tree no. 69), and no control in 5 (trees 71, 91, 95, 96 and 117). In view of data which are presented later in this report, it is believed that the tags on branches treated with boron and magnesium respectively on tree 93 may have been interchanged. In the branch on tree 69 in which there was considerable reduction in the percentage of corky core as compared with the checks, it should be noted that this branch was directly below the boron branch and only 8 inches removed from it, suggesting the possibility of some of the boron reaching it.

Magnesium sulphate wet injections:—2 branches treated, no control in one (tree 95) and very slight control in the other (tree 69). The latter branch was considerably injured, which probably accounts for the very slight reduction.

Magnesium sulphate spray:—2 branches treated, no control in tree 46 and considerable reduction in tree 47. In addition, spraying failed to give any control in 1934 on the two branches on trees 35 and 90 respectively.

TABLE 2.—RESULTS OF 1935 CORKY CORE INVESTIGATIONS

Tree no.	Variety	Branch no.	Treatment	Diameter of branch	*Amt. of chemical injected	Date of treatment	Percentage Corky Core						Remarks
							No. apples exam.	Sl.	Med.	Sev.	Total	1934 cork record	
				in.	gm.			%	%	%	%	%	
19	Fameuse		Check				29	51	0	0	51	100	Small tree
		1	Borax—dry	1.5	.12	Aug. 5	21	0	0	0	0		
35	Fameuse		Check				37	5	14	16	35	41	Small tree
		1	Borax spray (0.012% B)	1.0		Sept. 5/34	6	0	0	0	0		
36	Fameuse		Check				62	39	10	0	49	86	Small tree
		1	Zinc Sulphate—dry	1.4	1.6	July 29	5	40	0	0	40		Severe injury. Many leaves killed.
		2	Borax—dry	1.2	.4	July 29	16	0	0	0	0		
44	McIntosh		Check				16	13	0	0	13		Mild type of cork.
		1	Boric Acid—wet			1934	14	0	0	0	0		10 of these apples very badly water-cored. Also 7 small, scabbed, presumably from this branch on ground. Several of these badly cracked.
46	McIntosh		Check				24	21	8	0	29	7	
		1	Borax—wet	3.0	1.5	Aug. 2	11	0	0	0	0		
		2	Magnesium Sulphate spray			Aug. 13	7	0	28	28	56		
		3	Borax spray			Aug. 13	15	0	0	0	0		
47	McIntosh		Check				59	27	31	3	61	25	
		1	Boric acid—wet	2.8	1.7	Aug. 5	105	°56	0	0	°56		
		2	Magnesium Sulphate spray			Aug. 13	14	7	7	0	14		
65	McIntosh		Check				290	23	32	0	55	13	
		1	Zinc Sulphate—wet	2.8	2.5	Aug. 5	36	19	11	0	30		Very slight injury—darkening of main veins.
		2	Borax—dry	2.6	.8	Aug. 5	80	†1	0	0	1		
		3	Borax Magnesium Sulphate —dry	3.2	.5 borax 9.6 $MgSO_4$	Aug. 5	106	‡7	1	0	8		

69	McIntosh		Check				271	29	10	1	40	50	
		1	Borax—wet	2.9	2.1	July 29	60	0	0	0	0		Apples badly dwarfed.
		2	Magnesium Sulphate—wet	3.02	69.3	July 29	19	16	10	0	26		Severe injury largely marginal.
		3	Zinc Sulphate—dry	2.6	1.7	July 29	—	—	—	—	—		Considerable injury of a slight to medium type. No crop.
		4	Borax—dry	2.1	.7	July 29	32	0	0	0	0		
		5	Magnesium Sulphate—dry	2.4	12.8	July 29	35	6	0	0	6		This branch directly under branch 1 and only 8 inches distant.
71	McIntosh		Check				22	18	50	0	68	22	Light crop.
		1	Magnesium Sulphate—dry	1.8	10.8	Aug. 9	3	0	100	0	100		Very slight foliage injury.
		2	Zinc Sulphate—dry	2.4	1.5	Aug. 9	9	11	44	0	55		Slight injury on 6 leaves only.
		3	Borax—dry	2.6	.8	Aug. 9	24	38	8	0	46		Considerable reduction in percentage infection and most of this of a mild type.
90	Fameuse		Check				48	38	0	0	38	65	Small tree.
		1	Borax—dry	1.6	.5	July 30	23	0	0	0	0		
91	McIntosh		Check				42	26	29	10	65	20	
		1	Magnesium Sulphate—dry	2.2	13.2	Aug. 9	10	70	0	20	90		
		2	Boric Acid—dry	2.2	.7	Aug. 9	24	21	0	0	21		Type of cork encountered in this branch a very mild form.
		3	Borax Spary			Aug. 9	20	0	0	0	0		
92	McIntosh		Check				48	10	21	6	37	43	
		1	Boric Acid—dry	2.6	.8	July 30	22	0	0	0	0		
		2	Zinc Sulphate—dry—pure	2.2	10.0	July 30	18	10	0	0	10		Considerable injury. Very slight form of cork. Branches 2 and 4 closely connected. Possibility of backing up.
		3	Borax—wet	2.6	1.7	July 30	10	0	0	0	0		
		4	Borax, Magnesium Sulphate—dry	1.8	.6 Borax 10.8 $MgSO_4$	July 30	10	0	0	0	0		
93	McIntosh		Check				28	11	7	7	25	38	Light crop.
		1	Zinc Sulphate—dry	2.6	1.7	Aug. 9	13	23	0	0	23		1 gm. Zinc Sulphate to 7½ gm. sugar.
		2	Magnesium Sulphate—dry	3.2	15.0	Aug. 9	11	0	0	0	0		
		3	Borax—dry	2.0	.6	Aug. 9	17	24	6	0	30		

° Modified cork—not typical cork.
† Very slight type.
‡ Affected apples on one small side-shoot.
* Quantities of chemicals only approximate.

TABLE 2.—RESULTS OF 1935 CORKY CORE INVESTIGATIONS—*Concluded*

Tree no.	Variety	Branch no.	Treatment	Diameter of branch	*Amt. of chemical injected	Date of treatment	Percentage Corky Core						Remarks
							No. apples exam.	Sl.	Med.	Sev.	Total	1934 cork record	
				in.	gm.			%	%	%	%	%	
95	McIntosh		Check				44	14	5	5	24	16	
		1	Magnesium Sulphate—wet	2.7	3.0	Aug. 15	10	0	30	0	30		Tags on branches 2 and 3 were probably interchanged.
		2	Magnesium Sulphate—dry	2.8	15.0	Aug. 15	7	43	28	0	71		
		3	Zinc Sulphate—dry	2.9	1.8	Aug. 15	15	0	0	0	0		
		4	Borax—dry	2.4	.8	Aug. 15	13	0	0	0	0		
96	McIntosh		Check				21	10	0	0	10		
		1	Zinc Sulphate—wet	2.8	2.5	Aug. 5	10	10	0	0	10		
		2	Zinc Sulphate—dry	2.5	1.6	Aug. 5	8	13	13	0	26		Mild injury quite generally distributed.
		3	Magnesium Sulphate—dry	3.3	15.0	Aug. 5	10	60	0	0	60		
		4	Borax—dry	2.1	.6	Aug. 5	10	30	0	0	30		
116	McIntosh		Check				24	13	4	0	17	24	
		1	Borax—wet			1934	25	0	0	0	0		
117	McIntosh		Check				41	32	24	2	58	29	
		1	Boric Acid—wet	2.9	1.7	Aug. 5	20	0	0	0	0		Greenish tinge to flesh.
		2	Magnesium Sulphate—dry	2.4	13 4	Aug. 5	9	22	44	0	66		
		3	Borax—dry	2.2	.7	Aug. 5	20	35	0	0	35		Very mild form of cork.

° Modified cork—not typical cork.
† Very slight type.
‡ Affected apples on one small side-shoot.
* Quantities of chemicals only approximate.

Zinc Sulphate wet injections:—2 branches treated, no control in one (tree 96), and slight control in the other (tree 65). The latter branch was injured, probably accounting for the slight measure of control.

Zinc Sulphate dry injection:—7 branches treated, no apples on one branch (tree 69), complete control in one (tree 95), slight control in 1 (tree 92), and no control in 4 (trees 36, 71, 93, 96).

Combined Magnesium Sulphate and Borax dry injections:—2 branches treated, good control in tree 65 and complete control in tree 92.

Boric Acid dry injections:—2 branches treated, complete control in tree 92 and fair control in tree 91. In the latter tree, the percentage of corky core in the treated branch was 21 as compared with 65 on the check branches. Moreover, the type of cork on the treated branch was a very mild form.

Boric Acid wet injection:—A boric acid wet injection applied in 1934 gave complete control in 1935 in a branch on tree 44.

Borax dry injections:—10 branches treated, considerable reduction in both percentage and severity of cork in two (trees 71 and 117), no control in 2 (trees 71 and 96), excellent control in 1 (tree 65) and complete control in 5 (trees 19, 36, 69, 90 and 95).

Borax wet injections:—3 branches treated, complete control in all 3 (trees 46, 69 and 92). In addition, borax injected into a branch on tree 116 in 1934 exercised complete control in 1935.

Borax spray:—2 branches treated, complete control in both (trees 46 and 91). In addition, borax applied to a branch on tree 35 in 1934 again exercised complete control in 1935.

The effectiveness of boron in controlling cork is indicated. This is in agreement with the findings of Atkinson (1) in New Zealand and McLarty (2) in British Columbia.

1934 Soil and Root Observations

Seven trees were trenched during the season, five being located in the Gagetown district, and 2 in the Experimental Station orchard, where corky core has never been noted. The observation trench was 6 feet long and extended down as far as any roots were found. The root distribution was plotted, and root and soil samples from the various soil horizons taken. The cytological examination of the roots and the chemical analyses of the soils were performed at the Central Experimental Farm by the Horticultural and Chemistry Divisions respectively.

The data concerning the trees, utilized in these trenching operations, are given in Table 3.

TABLE 3

No. of tree	Variety	Location	Incidence of Corky Core	Date trenched
36	Fameuse	Gagetown	Severe 86%	Aug. 31
38	Fameuse	Gagetown	Very slight 6%	Sept. 4
59	McIntosh	Gagetown	No cork 0%	Aug. 23
71	McIntosh	Gagetown	Slight 22%	Aug. 27
704	McIntosh	Gagetown	No cork 0%	Sept. 4
261	McIntosh	Exp. Stn.	No cork 0%	Sept. 8
280A	McIntosh	Exp. Stn.	No cork 0%	Sept. 6

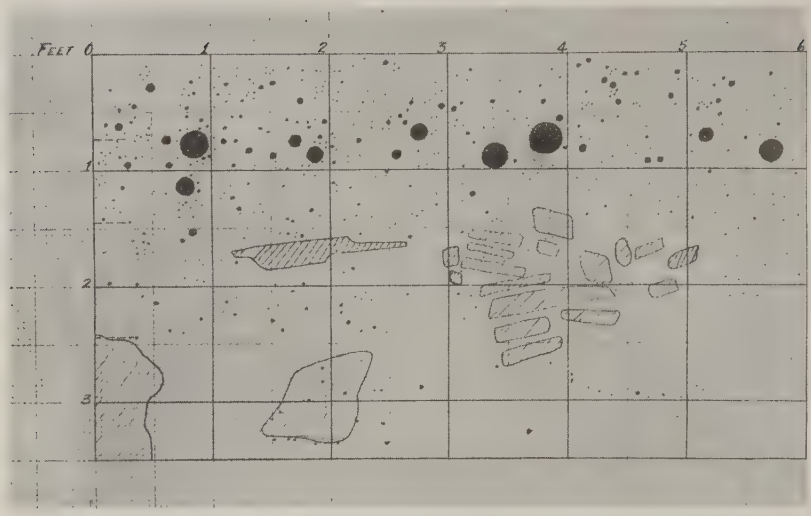

FIGURE 1. Face of Observation Trench in Tree 59, McIntosh, dug 4 feet from tree, showing distribution of roots.

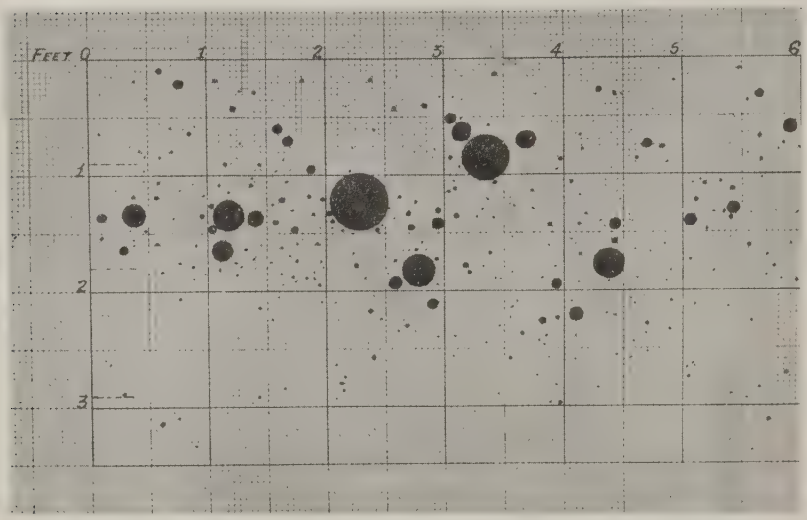

FIGURE 2. Face of Observation Trench in Tree 261, McIntosh, dug 4 feet from tree, showing distribution of roots.

Root Distribution

Inasmuch as the amount of corky core in individual trees varies from year to year, even reaching the point where a tree may be severely affected one year and free the next, negative results as to the occurrence of cork in any one year must be regarded as merely indicative. It is preferable, for purposes of comparison, to group trees as to whether or not they are located in affected blocks unless an individual tree record over a period of years is available. Following this idea, trees 36, 38, 59 and 71 are in a section of orchard in which corky core has been prevalent. Tree 704 is in a section of orchard, although on the same property, in which corky core has never been observed. Trees 261 and 280A are in the Experimental Station orchard in which corky core has never occurred.

In analyzing root distribution on this basis, it was noted that in trees 36, 38, 59 and 71 there was a tendency for a concentration of the larger roots in the upper 18 inches of soil. In trees 704, 261 and 280A, the larger roots were concentrated in the upper 24 inches of soil, with the 12″ to 24″ layer containing an unusually large number. In all trees, only a few scattered roots exist below the 36 inch level. A negligible number of dead roots were noted in all trees.

Figures 1 and 2 show the root distribution of trees 59 and 261 and are typical of the rooting systems encountered in diseased and non-diseased areas respectively.

Anatomical Study

Suit (4) examined the roots of McIntosh and Fameuse trees in the orchard of the Oka Agricultural Institute and noted a marked difference in the amount of plugging in the vascular ray cells between healthy trees and trees suffering from a physiological disorder. In every instance, the roots from affected trees showed a high amount of plugging in the cells of the vascular rays, whereas the sections from the normal roots showed only a very small amount of plugging in a few cases.

In order to examine these findings, root samples were collected from all trenched trees, and forwarded to Ottawa, where they were examined along with samples from trees in certain Quebec and Ontario orchards. Quoting from the unpublished report by A. W. S. Hunter, Horticultural Division, Central Experimental Farm, Ottawa, the observations were as follows: "It will readily be seen from the data presented that the Oka trees agreed very well with the findings of Suit, and that there the agreement stopped. Leaving the two Patton Greenings out of the question for the moment, it is obvious that there may be just as much plugging in a healthy tree as in a diseased tree, and just as little in a diseased tree as in a healthy tree. Thus in the Hadley, Edwards, Gagetown and Fredericton orchards, the plugging in the healthy trees was, at least in some roots, every bit as heavy as in the diseased Oka tree. Conversely, in the McCarthy and Tyndall orchards, most of the roots from the affected trees were as free from plugging as were those from the healthy Oka tree.

There appeared to be a marked variation in some instances in the amount of plugging at different points along the root. This variation was particularly noticeable in the roots from Gagetown and Fredericton trees, where the variation was sometimes as high as 100% in a distance of one-quarter inch."

Chemical Analysis of Soil

A complete chemical analysis of the soil samples, as performed by the Chemistry Division of the Central Experimental Farm, Ottawa, is presented in Table 4.

Although there is a wide variation in the different samples, it has been impossible to establish a correlation between any particular factor and the incidence of cork. Unfortunately, data concerning the boron content of the soils, are not available.

1935 Soil and Root Observations

Seven trees were trenched in five different orchards in the Gagetown area in order to determine if the conditions encountered in the previous year in the orchard in which the investigations had been concentrated, were typical of the district. The same general system of the plotting of root distribution and the taking of soil and root samples was again followed. These data, at the time of writing, are not available.

1936 Investigations

The boring of holes in trees, which is necessary when either wet or dry injection methods are followed, is very undesirable, especially if this practice has to be repeated annually. The 1936 investigations have therefore been outlined to test the merits of other methods of application. The possibility of applying boron in the form of a spray is being fully tested. Moreover, various methods of applying the material to the soil are being tried. These include:—

(1) *Broadcast Method:*—The borax is mixed with dry soil and scattered around the tree on the sod.

(2) *Pasture Method:*—Two steel plates, approximately 6 feet long and 4 inches wide, are driven down into the soil. They are then spread apart by driving wedges between them and the material dropped between, resulting in lines of borax at approximately 4 inches below the surface.

(3) *Drill Method:*—A number of holes, approximately 1 inch in diameter and 12 inches deep are made with a bar at intervals around the tree. These are then filled with the borax-earth mixture.

(4) *Water Method:*—The borax is dissolved in approximately 10 gallons of water which is poured around the tree on the surface of the ground.

The general rate of application is 1 pound of borax per tree with trunk diameter of approximately 7 inches. An experiment with trees 20 years old, and involving applications of borax at the rates of $\frac{1}{4}$, $\frac{1}{2}$, 1, 2 and 4 pounds per tree is also being carried on.

Although it is possibly too early as yet for damage to show up in the trees[3], the lack of severe damage to the grass growth is noticeable. An application of 4 pounds of borax per tree is equivalent to approximately 500 pounds per acre of sod. At the time of writing, which is seven weeks after the date of application, this heavy application of borax by means of the drill method, has not caused any damage to the grasses. When applied

[3] No damage was visible in the trees during the entire season.

TABLE 4.—ANALYSIS OF SOILS FROM APPLE ORCHARD, GAGETOWN, N.B.

Tree no.	Depth in inches	Total nitrogen	Moisture	Loss on Ignition	Total (Moisture-free basis)						Replaceable				Easily soluble phos.	pH	Sand	Silt	Clay	Classification
					SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	P_2O_5	CaO	MgO	K_2O						
		%	%	%	%	%	%	%	%	%	%	%	%	%	%			%	%	
36	0–6	.184	1.94	7.65	71.22	12.36	5.35	.74	1.00	1.49	.166	.179	.022	.009	.003	5.75	42.88	30.56	26.56	Clay loam
	6–12	.148	1.99	6.42	72.50	12.55	5.23	.70	1.08	1.35	.153	.128	.018	.007	.002	5.65	42.88	35.14	21.98	Clay loam
	12–18	.090	1.60	5.28	69.27	13.45	7.82	.74	1.44	1.78	.148	.094	.016	.007	.008	5.65	44.00	32.96	23.04	Clay loam
	18–24	.050	1.26	4.31	67.96	15.90	6.85	.74	1.84	2.47	.131	.072	.013	.007	.007	5.60	45.80	30.82	23.38	Clay loam
	24–36	.031	1.16	3.87	67.24	17.18	7.39	.84	1.79	2.34	.135	.165	.032	.005	.011	5.75	39.28	33.28	27.44	Clay loam
38	0–6	.213	2.10	8.19	71.98	11.50	5.28	.75	.85	1.39	.214	.139	.024	.013	.007	5.55	44.08	33.16	22.76	Clay loam
	6–12	.163	1.88	7.10	72.86	11.21	6.14	.57	.92	1.43	.169	.104	.017	.006	.002	5.58	45.22	33.66	21.12	Clay loam
	12–24	.114	2.25	7.18	60.35	19.40	8.11	.68	1.49	2.60	.281	Insufficient sample			.013	Insufficient				
	30–42	.018	1.05	3.49	70.15	15.46	6.96	.99	1.55	2.00	.141	.176	.033	.006	.020	6.25	48.12	28.76	23.12	Clay loam
59	0–6	.158	1.52	5.92	73.75	10.85	5.57	1 31	.98	2.62	.142	.422	.017	.011	.007	7.20	40.20	36.08	23.72	Clay loam
	12–18	.064	1.48	4.64	69.00	14.87	6.93	.68	1.59	2.34	.138	.118	.014	.006	.003	5.65	53.62	21.46	24.92	Sandy loam
	18–20	.046	1.15	3.93	67.97	15.94	7.72	.70	1.72	1.33	.122	.085	.016	.165	.009	5.80	55.19	24.73	20 08	Sandy loam
	30–42	.011	0.68	2.61	76 83	11.01	6.29	.76	1.25	1.41	.134	.118	.027	.007	.010	5.90	53.78	24 54	21.68	Sandy loam
71	0–6	.194	1.86	7.23	71.40	11.07	5.33	1.06	1.07	2.65	.234	.222	.028	.024	.009	6.15	52.12	27.65	20.22	Sandy loam
	6–12	.123	1.66	5.47	73.24	11.10	5.70	.74	1.06	2.09	.188	.122	.021	.007	.003	5.70	50.72	35.86	13.42	Sandy loam
	12–18	.093	1.72	4.68	71.54	13.16	6 21	.71	1.36	1.85	.142	.132	.020	.005	.003	5.55	42.52	36.28	21.20	Clay loam
	18–30	.038	1.12	3.20	68.05	15.34	7.87	.62	1 98	2.67	.064	.125	.022	.005	.002	5.55	28.22	46.00	25.78	Clay loam
	30–42	.042	1.31	3.36	61.22	19.14	10.35	.64	2.40	3.47	.142	.156	.035	.009	.011	5.65	21.22	44.30	34.48	Clay
704	0–6	.228	2.49	8.34	68.93	12.11	6 92	.63	1.24	1.62	.274	.134	.025	.012	.008	5.75	37.22	32.40	30.38	Clay
	6–12	.188	2.56	7.84	69.11	12.75	6.45	.60	1.29	1.62	.243	.122	.019	.012	.005	5.48	38.38	24.30	37.42	Clay
	12–22	.063	1.87	6.00	64.83	15.48	8.61	.53	1.73	2.20	.123	.049	.010	.008	.005	5.40	35.44	30.52	34.04	Clay
	22–42	.042	1.47	4.20	62.86	17.52	8.96	.60	2.16	2.86	.103	.112	.035	.009	.005	5.90	27.36	36.02	36.62	Clay
261	0–8	.142	1.58	6.29	71.82	12.79	5.36	.62	1.89	1.83	.149	.132	.013	.037	.007	6.25	47.86	36 00	16.14	Loam
	8–18	.078	1.88	5.37	71.42	13.51	5.57	.39	1.62	1.54	.117	.020	.002	.003	.003	5.20	51.16	40.08	8.76	Sandy loam
	18–33	.020	0.38	2.15	74.28	12.43	5.31	.53	1.78	1.12	.102	.041	.005	.007	.004	6.00	76.28	19.23	4.49	Sandy loam
	33–42	.017	0.60	1.96	74.30	12.43	5.46	.62	1.80	1.08	.116	.048	.010	.011	.005	6.00	71.35	20.47	8.18	Sandy loam
280	0–6	.261	2.15	8.27	69.98	11.43	5.07	1.06	1.42	1.04	.404	.353	.023	.054	.068	7.20	50.88	35.50	12.62	Sandy loam
	6–18	.070	1.29	3.83	73.54	12.12	4.87	.53	1.74	1.58	.103	.144	.002	.023	.005	7.20	66.10	28.34	5.56	Sandy loam
	18–31	.024	0.40	1.92	74.30	11.70	5.25	.50	1.70	1.24	.096	.174	.001	.013	.005	6.95	80.55	17.17	2.28	Sand
	31–44	.007	0.38	1.30	76 69	11.64	4.10	.62	1.51	1.54	.108	.031	.003	.022	.004	6.95	53.00	41.1	5.90	Sandy loam

by means of the water and broadcast methods, some damage to the grasses has resulted. This damage is not evident at a distance, but only upon close examination.

SUMMARY

(1) The application of boron, either in the form of a wet or a dry injection exercises an important controlling effect upon the prevalence of corky core in apples. The effectiveness of boron, applied in the form of a spray is also indicated.

(2) The application of magnesium or zinc failed to control corky core.

(3) Isolated instances of failure of boron to control corky core are noted.

(4) Corky core has been noted in orchards with varying degrees of fertility, and even in trees growing practically in the wild.

(5) Corky core fluctuates in intensity from season to season. Trees severely affected in a given year may be free the next.

(6) A study of root distribution has indicated a tendency for a concentration of the larger roots at greater depths in non-affected areas than in areas in which corky core is prevalent. Negligible numbers of dead roots were observed in all areas.

(7) The anatomical examination of roots indicated a lack of correlation between plugging of the vascular ray cells and disease.

(8) The chemical analysis of the soil indicated a wide variation in the different samples, with no definite correlation between any particular factor and the incidence of cork. Unfortunately, data concerning the boron content of the soils are not available.

(9) The boring of holes in trees in both wet and dry injection methods is undesirable. The application of boron in the form of a spray is a promising substitute. Soil applications are also being studied. Soil applications of borax, at the rate of 4 pounds per 20 year old tree have failed to produce visible injury to the trees at a date seven weeks after the time of application.

ACKNOWLEDGMENTS

Acknowledgments are made to Mr. M. B. Davis, Dominion Horticulturist, for suggestions and advice during the course of these experiments, to Mr. A. W. S. Hunter for the anatomical examination of roots, and to Mr. C. H. Robinson, Dominion Chemist for the chemical analysis of the soil samples.

REFERENCES

1. Atkinson, J. D. Progress Report on the Investigation of Corky Pit of Apples. The New Zealand Journal of Science and Technology. March, 1935.

2. McLarty, H. R. Tree injections with boron and other materials as a control for drought spot and corky core of apples. Sci. Agr. 16 : 625-633. 1936.

3. Roach, W. G. Annals of Applied Biology, 21 : 333-343. 1934.

4. Suit, R. F. Report of the Quebec Society for the Production of Plants. 1930–32.

Résumé

Rapport sur l'étude du cœur liégeux des pommes. L. C. Young et C. F. Bailey, station expérimentale fédérale, Fredericton, N.-B.

Le cœur liégeux, une maladie physiologique des pommes qui affecte les variétés Fameuse et MacIntosh, est à l'étude depuis 1933. Trois éléments, le bore, la magnésie et le zinc, ont été appliqués directement aux arbres sous forme d'une injection humide ou sèche, ou sous forme de pulvérisation. L'application de bore, sous forme d'injection humide ou sèche, a enrayé d'une façon marquée la propagation de la maladie. L'efficacité du bore, appliqué sous forme de pulvérisation, était indiquée également. Le magnésium et le zinc sont restés sans effet. Une étude de la distribution des racines indique une tendance à la concentration des grosses racines à de plus grandes profondeurs dans les régions non affectées que dans celles où le cœur liégeux sévit. L'analyse chimique du sol des différents horizons a révélé de grandes variations, sans indiquer de corrélation entre un facteur particulier et la fréquence du cœur liégeux. Il n'existait aucune donnée sur la teneur en bore du sol. Les applications de borax au sol à raison de quatre livres par arbre âgé de vingt ans, n'ont causé aucun tort visible aux arbres pendant l'année de l'application.

ANALYTICAL OBSERVATIONS ON THE CHANGES OF PECTIC SUBSTANCES AND SUGARS IN CELERY DURING COLD STORAGE[1]

R. H. White-Stevens[2]

Department of Horticulture, Macdonald College, Que.

PECTIN STUDIES

Corbett and Thompson (4) maintain that a periodic examination of the pectic constituents of the middle lamella of celery in cold storage reveals a progressive condition of cytolysis. Such a condition of cytolysis, if present in the absence of any pathogenic organism indicates natural senescence. It was decided, therefore, to investigate this aspect of the problem in the hope that a definite criterion of storage maturity would be forthcoming.

The literature concerned with the constitution, function and decomposition of pectins is still somewhat confusing, especially in regard to terminology of the various pectin types. The literature prior to 1925 is reviewed by Ahman and Hooker (1) and the reader is referred to that reference for early details on the chemistry of plant pectins.

The work of Nanji and Norman (7) was followed both in regard to technique and terminology. According to these workers there are three essential pectin types based upon solubility differences. These are:

1. *Pectic Acid.*—Its major properties are: acid, very slightly soluble in water, readily gelled with dilute HCl and alcohol, soluble in 0.5% ammonium oxalate, tartrate and citrate, insoluble in oxalic acid.

2. *Water Soluble Pectin.*—Essentially the fully methylated pectic acid, with major properties: ready solubility in water, precipitated by dilute HCl and alcohol, soluble in 0.5% solutions of oxalic acid and ammonium oxalate.

3. *Protopectin*—(Ahman and Hooker (1) include insoluble pectic esters too, under this term) presumably the calcium and magnesium salts of pectic acid that occur normally in the middle lamella. Nanji, and Norman (7) suggest that iron salts also occur in the middle lamella, and that in some cases a combination of all three may be present. Its chief properties are insolubility in water, solubility in 0.5% oxalic acid and ammonium oxalate solution, ready precipitation by dilute HCl and alcohol.

For the purpose of conciseness and clarity only the three italicized terms outlined above will be employed throughout this paper to denote the different pectin types dealt with.

Materials and Methods

The celery employed in this work was the Golden Self Blanching (Tall Strain) variety. The crop was grown at Macdonald College during the summer of 1934. The plants were raised in the college greenhouses during

Read before a meeting of the Horticultural Group of the C.S.T.A. at the University of New Brunswick, Fredericton N.B., July 14–15, 1936.

[1] Reported from experiments conducted under the direction of the Macdonald College Muck Soil Committee 1932–35. A complete report of the more important phases of investigations with celery grown on muck soil for cold storage purposes is contained in a master's thesis, which has been presented to the graduate school, McGill University, in partial fulfilment of the requirements for the degree of Master of Science.

[2] Graduate student in Horticulture 1933–35, specializing in vegetable crops.

April and May when they were kept in flats outside until about the 20th of June, at which time they were removed to the field and planted. The soil used was a rich, well-drained unfertilized muck, which had previously grown grain and field crops. The comparatively dry season that followed necessitated artificial irrigation. The crop was harvested in October, a few days after a slight frost, and transferred to cold storage in Montreal[3] The cold storage was maintained at a temperature of 32° F. ± 0.7° F. and a relative humidity of 95% ± 3%.

At intervals during the storage period (cf. Table 1) composite samples were selected for analysis. These invariably consisted of 6 to 12 plants according to their size. Those samples selected were carefully examined for signs of infection from pathogenic organisms, and only those samples which appeared definitely free from such infection were employed for analysis. During the latter portion of the storage period no plants were found to be entirely free from the rotting activity of the storage pathogenes and in those cases only the sound, apparently uninfected, portions of the plant were selected for analysis. On removal from the storage, the samples were taken immediately to the laboratory and prepared for analysis on the same day, generally within three hours.

The analytical technique adopted was that outlined for apples by Nanji and Norman (7); however, as some variations were employed for the analysis of celery, the actual technique used is here given in detail.

The selected material was sliced three to five mm. thick and laid out in thin layers over the surface of large, previously weighed, evaporating dishes, which were then weighed again. These were placed in an electric oven, kept constantly at 98° C. From observation of the oven temperature it was found that 10 to 15 minutes was sufficient to bring the dishes and their contents to a temperature above the maximum point for the activity of any plant enzymes (i.e. above 80° C.) and within one-half hour the oven temperature was quite constant. Drying was continued until the whole had attained a constant weight, which usually required about 12 hours. The completely dried material was then cooled in a desiccator and the water loss determined by weighing. The dried celery was then removed to a mortar and ground to pass a 40-mesh sieve.

From the powder, three 5 gm. samples were carefully weighed into three round-bottom flasks, which were separately treated as follows:

Flask A—to which 200 cc. of distilled water was added.

Flask B—to which 200 cc. of 0.5 per cent oxalic acid solution in distilled water was added.

Flask C—to which 200 cc. of a 0.5 per cent ammonium oxalate solution in distilled water was added.

The three flasks were then set in a constant level water bath, adjusted with reflux condensers and heated at 85° C. for 24 hours. The apparatus was then dismantled and the contents of each flask filtered, the filter being washed with a little of the respective solvent in each case, to ensure quantitative separation of the pectin extract.

[3] The writer wishes to express his appreciation to the authorities of the Montreal Harbour Cold Storage for their assistance and kindness in providing storage for the crop and aiding in its care while there.

Each filtrate was then made to volume at 300 cc. and two aliquots of a 100 cc. each were drawn off into evaporating dishes and evaporated to about 25 cc. In the case of the solution B the 100 cc. aliquot was first neutralized with dilute NH_4OH solution before proceeding with evaporation. The digested solutions were then quantitatively removed to three flasks and to each was added about three and one-half volumes of alcohol acidified with HCl. The pectins became precipitated at this point. The whole was allowed to stand for five hours or longer, when the gelatinous precipitates were filtered off on fluted filter paper, and, in the case of B and C, the precipitates were washed free of oxalate with more alcohol. The precipitates were then redissolved as follows.

The filter papers and precipitates from the duplicate samples of A and of B were boiled for two minutes in distilled water and the resulting solutions filtered. The original filter papers were then boiled a second time in dilute NH_4OH solution instead of water and these solutions also filtered into the previous filtrates. The second filter papers were then added to the first and the two lots well triturated with a glass rod and boiled for five minutes in distilled water, these solutions being filtered into the previous two. Finally, the third filter papers were carefully washed with hot dilute NH_4OH solution, the washings being collected in the previous filtrates.

Filter papers of the C samples were first boiled in the ammonia solution and then in distilled water, otherwise the procedure was the same as that for A and B.

This careful dissolution of the pectin precipitates is essential to ensure every particle of pectin passing on to the later stages.

The completed solutions were then cooled and to each was added 100 cc. of a 0.4 per cent NaOH solution. They were then left to stand for 24 hours or longer.

Finally, each saponified solution was acidified with 50 cc. of normal acetic acid and the pectin present, as sodium pectate, precipitated as calcium pectate by the addition of 50 cc. of 11.1 per cent $CaCl_2$ solution in distilled water -the Carre and Haynes (3) method. This precipitate was then boiled five minutes and filtered hot through tared and fluted Whatman No. 1 filter paper, the funnel being supported in a constant temperature heated water jacket to maintain a high temperature during the filtration. This point was found to be most essential, for even with careful precautions filtration is slow and much time may be wasted by allowing the precipitate and solution to cool. The excess $CaCl_2$ was removed by continuous washing with hot distilled water; this was continued until not the slightest indication of a white precipitate was to be seen in the filtrate, upon the addition of $AgNO_3$ solution. The cleaned filter and calcium pectate were then dried to constant weight in an oven at 95° C., cooled in a desiccator and weighed.

Determination

According to Nanji and Norman (7) the relative amounts of protopectin, pectic acid and water soluble pectin may be determined from the resulting calcium pectate precipitates from the following relations:

Precipitate A—comes from water soluble pectin.

Precipitate B—comes from water soluble pectin and protopectin.

Precipitate C—comes from water soluble pectin protopectin and pectic acid.

Whence A = water soluble pectin or its equivalent.

B − A = protopectin or its equivalent.

C − B = pectic acid or its equivalent.

Experimental Results

Owing to the apparent uncertainty as to the true formulas of the pectin compounds it appears unwise to attempt to calculate any relation between final precipitates and the original pectic constituents within the fresh plant. However, since the chief interest of this study lies in the comparative quantitative changes of the different types during the storage period, no effort for the calculation of pectic substances back to the living plant has been made. The results are therefore presented solely as weights of final precipitate of calcium pectate produced from 100 grams of dry material for the different types of pectin compounds. The accompanying table gives the relative amounts of calcium pectate derived from the three pectic types, together with water content from twelve determinations throughout the storage period. Samples 1 to 11 inclusive, may be considered as free from pathogenic rots; sample 12 was selected from completely decayed material, the rot in major being unquestionably due to the activity of soft rotting pathogenes.

Discussion of Results

One fact stands out paramount among the results; the soluble pectin becomes high only when the plants are infected with soft rotting pathogenes. This point is of extreme significance, for from the work of Corbett and Thompson (4) it appeared that an increase in water soluble pectin was a natural manifestation of storage senescence. Yet upon making quantitative determinations, this does not appear to be the case, at least under the conditions in which this experiment was conducted.

Corbett and Thompson do not mention the presence of disease rots on the celery they investigated, but from the general tenor of their description it would appear extremely probable that a considerable amount of pathogenic activity took place in their material. The fact that the storage temperature, with which they were working, showed fluctuations from 32° 40° F. would indicate that rots played a significant part in the breakdown of their product. Furthermore, these workers did not consider the problem from the quantitative angle and, consequently, it becomes difficult to compare their results with those of the writer.

In other studies conducted by the writer on the disease relations of celery in cold storage, it has been found that considerable pathogenic decay is responsible for celery breakdown at temperatures above 35° F., whereas, at 32° F. the bulk of these organisms did not grow at all.

TABLE 1.—PECTIN STUDIES OF CELERY IN STORAGE. TABLE SHOWING RELATIVE CHANGES OF PECTINS IN CELERY IN COLD STORAGE AT 32° F.

Sample number	Days in storage at 32° ± .7 F.	Water per cent of fresh weight	Final ppt. calculated as calcium pectate per 100 gms. of original dry material			
			Proto-pectin gms.	Pectic acid gms.	Water soluble pectins gms.	Total pectins gms.
1	0	93	2.2	3.0	0.1	5.3
2	17	93	3.5	2.7	0.4	6.6
3	42	93	3.8	2.3	0.3	6.4
4	49	91	3.8	6.1 ?	0.3	10.2 ?
5	56	93	3.8	3.2	0.4	7.4
6	64	93	3.4	3.7	1.0	8.1
7	71	93	3.1	4.3	0.4	7.8
8	77	93	3.6	3.6	0.4	7.6
9	90	93	4.0	2.7	0.1	6.8
10	98	91	5.0	3.7	0.2	8.9
11	126	92	2.2	8.9	0.3	11.4 ?
12	Diseased sample	96	0.0	1.1	5.5	6.6

A degree of fluctuation was found in pectic acid but, with the exception of samples 4 and 11, the totals check within a range expected from the effects of random sampling At all events, the essentially significant figures are those of water soluble pectin, which remain uniformly low until sample 12, indicating the marked effects of pathogenic rot on the hydrolysis of the plant pectins. Thus it may be tentatively concluded that little or no cytolysis occurs during the cold storage of celery in the absence of pathogenic organisms and that soft rot of celery, so frequently encountered as the main delimiting factor in the longevity of celery in the cold storage, is in the main primarily due to the activity of divers pathogenic bacteria and fungi.

SUGAR STUDIES

The food value of celery largely depends upon its sugar content. It therefore seemed advisable to obtain data upon the changes in carbohydrates which occur during the storage period.

Corbett and Thompson (4) found a definite increase, followed by a decline in hexose sugars, during storage of celery between temperatures ranging from 32° F. to 40° F. but do not show a marked trend in their values for sucrose. Rose et al. (8) show that the respiration heat, produced by celery at 40° F., is more than three times that produced at 32° F.,—2606 and 704 B.T.U. per ton per 24 hours respectively. Magness and Diehl (6) show a similar relation for apples in cold storage.

Thus it appears that such fluctuating storage temperatures as those experienced by Corbett and Thompson would tend to have marked effects upon the consistency of their results.

The figures given by Rose et al. would indicate that in the absence of any other limiting factor, the storage life of celery stored at 32° F. is distinctly restricted by dint of its own respiration. It was with this point in view that the following analysis was undertaken.

Materials and Methods

The celery used for this analysis was identical with that used for the pectin studies (cf. above). The samples were taken from the same selections, in most cases at the same time, as those for pectin analysis.

The prepared petioles, i.e., from the first node down including the crown, were sliced into sufficient boiling 95% alcohol to make a final concentration of 80% and containing a small quantity of calcium carbonate. The whole was digested for 10 to 15 minutes, cooled and filtered, when the bagasse was removed and pounded in a mortar with 80% alcohol and re-extracted as before. Three extractions were so conducted before the bagasse was discarded.

The method of clearing was that suggested by Loomis (5)—using neutral lead acetate to remove protein and potassium oxalate to remove the excess lead. Determination of sugars was carried out by Soxhlet's improved Fehlings method, outlined in the *Methods of Analysis of the Association of Official Agricultural Chemists (1925)*. Inversion to obtain total sugars was effected with dilute HCl following the technique outlined in the same publication.

Triplicate readings were made for both hexose and total sugars from each original sample. Results given represent the means of these. Sucrose percentages were obtained in the usual manner from hexose and total sugars by difference.

Experimental Results

Table 2 gives the observed changes in hexose and sucrose sugar calculated as percentages of dry weight.

TABLE 2.—CHANGES IN REDUCING AND NON-REDUCING SUGARS IN CELERY DURING COLD STORAGE AT 32° F. ± 0.7° F.

Sample number	Days in storage	Reducing sugars (hexose) gm. % of dry wgt.	Non-reducing sugars (sucrose) gm. % of dry wgt.	Total sugars, calculated as hexose gm. % of dry wgt.
1	0	4.7	4.6	9 5
2	18	5.2	7.6	13.2
3	47	7.3	4.6	12.1
4	68	8.0	3.3	11.5
5	75	8.4	3.5	12.1
6	103	6.3	3.1	9.6
7	131	2.2	0.2	2.4

Discussion of Results

It is interesting to note the rapid increase of sucrose during the early stages of the storage period, followed by a rise in hexose concomitant with a corresponding decline in sucrose. The maximum concentration of hexose appears early in the storage period i.e. 75 days at 32° F. following which the total sugars decline markedly. This would indicate that respiration is proceeding fairly rapidly and that after 75 days hexose is being respired

at a greater rate than it is being formed by hydrolysis of higher carbohydrates.

However, as was mentioned under the pectin studies, all of the celery showed signs of pathogenic decay, mostly at the butts and in the leaves, towards the end of the storage period and, although the parts used for analysis were apparently free from any infection, the fact that the plant was infected elsewhere might reasonably be responsible for the rapid decline in total sugars at that time.

TABLE 2-A.—REDUCING AND NON-REDUCING SUGARS IN CELERY DURING COLD STORAGE AT 32° TO 42° F. (ADAPTED FROM CORBETT AND THOMPSON 1925)

Days in storage	Reducing sugars (hexose) gm. % of dry wgt.	Non-reducing sugars (sucrose) gm. % of dry wgt.	Total sugars, calculated as hexose gm. % of dry wgt.
(Week before harvest)			
−7	2.5	No reading	—
(Harvest)			
0	7.2	1.5	8.8
11	7.3	6.8	14.5
26	11.8	5.1	17.2
40	13.3	7.8	21.5
64	11.2	9.1	21.3
72	9.5	9.1	19.6

* Cf. text.

These results can only be considered as indicative of a general trend in the sugar changes of celery in storage and not as an accurate indication of carbohydrate changed due to respiration. Although it may be mentioned that Barnes (2) has found a remarkably similar relation for changes in hexose and sucrose in carrots stored at 32° F.

An interesting comparison may be drawn from the figures of Rose et al. for the respiration of celery kept at 32° F. They find that one ton of celery will at 32° F., produce 750 B.T.U. of heat every 24 hours. Assuming, as they do, this heat is produced solely by the respiration of a hexose sugar and that such a reaction takes place in the following relation:

$$C_6H_{12}O_6 + 6\ O_2 = 6\ CO_2 + 6\ H_2O + 674\ \text{Calories}$$

Then it follows, since 674 Calories of heat are produced from 180 grams and 750 B.T.U. are equivalent to 189 Calories, that 0.1113 pounds of sugar are respired every 24 hours from each ton of fresh celery. Calculated as percentage of dry weight, this would be approximately 0.08 per cent every 24 hours.

Such a respiratory rate would entail a loss of sugars approximating that observed after the hexose had reached its maximum in sample 5. The marked decline between samples 6 and 7, however, is too rapid to agree with the above respiratory rate and must be attributed to some other cause, probably increased infection from organisms. There is a reasonable agreement in the results for total soluble sugars with the figure given by Rose et al., sample 7 being again too low.

Together with Table 2 is a table of sugar changes, adapted from Corbett and Thomspon—Table 2-A. An assumption is made that their celery contained 93% water and the calculations include inner and outer petioles only, the leaves being excluded. These adapted figures show a marked relation in regard to hexose to those of the writer, but the sucrose observations differ radically. Total sugars, however, show a similar trend. There appears to be no satisfactory explanation why the sucrose remains as high as the hexose after 72 days of storage. Certainly the fluctuating temperatures of 32° F. to 40° F. would effect marked changes in respiratory rate but one would anticipate a greater loss of sucrose rather than a gain towards the later period of storage.

SUMMARY

An attempt has been made to correlate storage maturity with pectin and sugar changes of celery in cold storage at 32° F.

A detailed technique for the quantitative comparison of the different pectic constituents is given.

There appears no definite correlation between pectic hydrolysis and storage maturity, apart from the cytolytic effects of storage pathogenes.

Sucrose sugars show a marked increase in the early part of the storage period, ultimately declining with a simultaneous increase in hexose, which in turn reaches a maximum and then likewise declines.

Assuming sugar content to be a major property of food value in stored celery, it would seem that the optimum duration of celery in cold storage at 32° F. is approximately between 60 and 100 days, after which its food value declines rapidly. This is but a generalization, for it is possible that such factors as variety, cultural treatment, time of planting and harvesting may affect the loss of sugars markedly.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to those who made this work possible, more especially to Professors T. G. Bunting and H. R. Murray of the Horticultural Department, who suggested the problem and gave the advice and assistance necessary in the field and storage work. The writer also wishes to express his thanks to Drs. G. W. Scarth and R. D. Gibbs, of the botany department, McGill University, for their assistance and guidance in the actual laboratory analyses and for the use of their laboratory and apparatus.

REFERENCES

1. Ahman, C. F. and Hooker, H. D. The estimation of pectin and a study of the constitution of pectin. Univ. of Miss. College of Agriculture. Agr. Exp. Sta. Res. Bul. No. 77. 1925.

2. Barnes, W. C. Effect of some environmental factors on growth and color of carrots. Cornell University Agr. Exp. Sta. Memoir 186 : 3. 6 pp. 1936.

3. Carre, M. H. and Haynes, D. The estimation of pectin as calcium pactate and the application of this method to the determination of the soluble pectin in apples. Biochem. Jour. 16 : 19. 1922.

4. Corbett, L. W. and Thompson, H. C. Physical and chemical changes in celery during storage. Amer. Soc. Hort. Sci. Proc. 1924, p. 346-353. 1925.

5. Loomis, W. E. A study of the clearing of alcoholic plant extracts. Plant Phys. 1 : 179-189. 1926.

6. Magness, J. R., Diehl, H. C., Haller, M. H. and Graham, W. S. The ripening, storage and handling of apples. U.S.D.A. Bul. No. 1406. 1926.

7. Nanji, D. R. and Norman, A. G. Studies on pectin Pt. II. The estimation of the individual pectic substances in nature. Biochem. Jour. 22 : 596-604. 1928.

8. Rose, D. H., Wright, H. C. and Whiteman, T. M. The commercial storage of fruits and vegetables and florists stocks. U.S.D.A. Circ. No. 278. 1933.

9. Methods of Analysis of the Association of Official Agricultural Chemists, for 1925.

Résumé

Observations analytiques sur les transformations des substances pectiques et des sucres dans le céleri, au cours de la conservation au froid. R. H. White-Stevens, Service de l'horticulture, Collège de Macdonald, Qué.

Trois dissolvants différents, l'oxalate d'ammonium (solution aqueuse à 0.5%), l'acide oxalique (solution aqueuse à 5%) et l'eau, ont été employés pour déterminer les quantités relatives d'acide pectique, de protopectine et de pectine soluble dans l'eau, respectivement, que renferme le céleri cultivé sur tourbe, à onze époques différentes au cours de la conservation (32° F.). Il n'a pas été constaté de tendance marquée à un changement d'une forme aux autres, comme conséquence normale du séjour en entrepôt, mais les matériaux infectés de microbes pathogènes d'entrepôt ont révélé une augmentation excessive de la pectine soluble dans l'eau et une diminution correspondante des autres formes de pectine, par comparaison aux matériaux non infectés. Ceci indique que la cytolyse ne se produit dans l'entrepôt froid que lorsque la substance végétale est infectée des microbes pathogènes qui causent la pourriture molle.

Les observations sur les transformations des sucres à sept phases de l'entreposage ont révélé une augmentation rapide de sucrose dans la première période de la conservation, suivie d'une augmentation dans le pourcentage d'hexose et d'une diminution correspondante dans la sucrose. Plus tard l'hexose a diminué également. Le taux de diminution des sucres totaux, après qu'ils ont atteint le maximum, a suivi de près les calculs théoriques basés sur les données relatives aux taux de la respiration, obtenues par d'autres investigateurs.

RESPONSE OF THE TOBACCO PLANT TO FERTILIZERS IN SOUTHWESTERN ONTARIO[1]

By R. J. Haslam[2] and H. F. Murwin[3]
Dominion Experimental Station, Harrow, Ontario

INTRODUCTION

It is a well-known fact that the tobacco plant is extremely sensitive to nutrients that are commonly applied in the form of commercial fertilizers. The present paper deals particularly with fertilizer experiments conducted in southwestern Ontario during the past twenty years. Before considering these experiments, however, it might be of value to briefly outline certain specific facts associated with this highly specialized industry in Ontario.

The production of tobacco is confined more or less to the Lake Erie region of southwestern Ontario. The tobacco area at present may be divided into two belts: Essex and Kent Counties are the pioneer districts and form the old belt; Norfolk, southeast Elgin, and the southern portion of Oxford and Brant Counties, having come into production during the past ten years, are commonly referred to as the new tobacco belt. The Dominion Experimental Station at Harrow and the Dominion Experimental Substation at Delhi are centrally located in the old and new belts, respectively.

The area of all types under cultivation in 1936 amounts to approximately 45,000 acres, of which 77% is of the flue-cured type, 18% of the burley type, and 5% of the dark type. Based on the above acreage, tobacco growers in southwestern Ontario used approximately 20,000 ton of commercial fertilizers or slightly less than 10% of the total quantity utilized in Canada during the past year. The new belt at present is producing more than 30,000 acres or 85% of the flue-cured type. The old belt produces the remainder of the flue-cured and also the entire crop of burley and dark tobaccos.

Tobacco will grow on practically any soil, but unless the texture of the soil lends itself favourably to the development of those specific qualities in the growing plant which will allow the leaf to mature and cure properly, it will be of little or no commercial value. This is particularly true of the cigarette types. The most essential soil factors for the production of good quality tobacco are, therefore, adequate drainage, good aeration, and an easily workable soil. Natural soil fertility may be regarded as being secondary in importance.

Flue-cured is the most sensitive type of tobacco in its plant-food requirements and is adapted only to the lightest soils. The supply of nitrogen available to the plant must be controlled; otherwise growth will continue for too long a period, thus seriously delaying normal maturity and impairing the curing qualities of the leaf. The high unit production per farm which ranges from 20 to 30 acres makes flue-cured tobacco-growing a specialty in itself. It requires a short rotation devoid of leguminous

[1] Read before a meeting of the Horticultural Group of the C.S.T.A. at the University of New Brunswick, Fredericton, N.B., July 14–15, 1936.

[2] Tobacco Specialist.

[3] Superintendent.

26664—3

crops, but may be also grown in continuous culture satisfactorily, provided mosaic or black root-rot are not serious factors. The chief source of humus is fall rye and light periodic applications of barnyard manure.

Burley and dark tobaccos, on the contrary, are less specialized in soil and nutrient requirements. With these types high yield and good quality are more closely associated than with flue-cured tobacco. The soil, therefore, must be well supplied with organic matter. The mineral constituents must also be available in the proper relationship for normal growth and maturity, as excessive quantities of slowly available nitrogen delay maturity and also seriously affect the colour of the cured leaf. Burley and dark tobaccos are most frequently grown in rotation with other crops.

FERTILIZER EXPERIMENTS

Early Work at Harrow

Although this paper deals mainly with the results of experiments conducted subsequent to 1928, mention must be made of the work that was carried on between 1916 and 1928[4]. The experiments conducted during that period were valuable to an industry which was just entering a period of transition and expansion. During this period dark tobacco was introduced into Western Ontario. The demand for a finer type of

FIGURE 1. Burley fertilizer experiments at the Harrow Station: (left) plot fertilized with a complete fertilizer 4-8-12; (right) plot fertilized without phosphoric acid 4-0-12.

burley tobacco was becoming more evident, and since 1925 the new flue-cured belt has developed rapidly. The information acquired from experiments indicated very clearly that fertilizers were practically indispensable for normal growth and maturity of the tobacco crop. Results also showed that inasmuch as a complete fertilizer was necessary for tobacco, the proper relationship of the major nutrients supplied in the fertilizer mixture was

[4] See reports of the Chief of the Tobacco Division, Ottawa, 1916–24, and the reports of the Superintendent of the Dominion Experimental Station, Harrow, 1926–28.

equally important if a good-quality product was to be expected. When the fertilizer experiments were reorganized in 1929, the former data furnished a useful basis for formulating a new series of experiments.

Recent Work at Harrow and Delhi

A new series of experiments was begun at Harrow[5] in 1929 and at Delhi in 1933. These tests dealt specifically with the quantitative relationship of the various plant nutrients and also with some of the more outstanding plant-food sources. At Harrow investigations were conducted on all three types of tobacco, while at Delhi the experiments were confined to the flue-cured type.

Methods of Experimentation

All treatments were applied on quadruplicate plots $\frac{1}{252}$ of an acre in size. The tobacco from the middle portion of each plot, which usually consisted of two or four rows, was harvested for yield and quality data. A standard mixture known as the basal formula was used as a check and was repeated on every fifth plot in the field. The nitrogen, phosphoric acid, and potash were each varied individually in these experiments and the remainder of the basal mixture was kept constant. A constant rate of fertilization consisting of 1000 pounds per acre or its equivalent was used throughout, except as otherwise designated. The tests at Harrow were conducted continuously on the same plots for a period of six years. A winter crop of rye was ploughed under each spring. During the final year of the tests on burley tobacco barnyard manure was applied to two replications to ascertain its effect on the treatments; otherwise, the rye cover crop was the only source of humus. The system of plotting at Delhi was similar to that at Harrow except that the treatments were applied in a two-year rotation with tobacco alternating with rye. The cured leaf tobacco was sorted into commercial grades and the quality numerically expressed as the grade index.

Responses from Nitrogen

When nitrogen was supplied at various levels in the basal mixture, the results were more striking with flue-cured than with either burley or dark tobacco. At Harrow 12, 24, 32, and 40 pounds of nitrogen were compared on flue-cured tobacco while at Delhi the levels were set at 10, 20, and 30 pounds per acre. As will be observed from examination of Table 1, the results point conclusively to the advisability of controlling the nitrogen in the fertilizer for flue-cured tobacco. While the yield was increased by increasing the quantity of nitrogen, the quality of the cured leaf was definitely impaired with each increase. The most profitable nitrogen level appears to be around twenty pounds per acre. A reduction beyond this point produced a thin, papery leaf accompanied by a reduced yield, while an increase in the application resulted in delayed maturity and a coarser leaf of a lower grade index.

One-quarter of the total nitrogen in the flue-cured basal formula was supplied by dried blood, an organic source. This was compared with a formula which differed only in that one-half of the nitrogen was derived from dried blood. In every case the grade index was somewhat higher and the yield lower with increasing proportions of nitrogen in the organic

[5] See reports of the Superintendent of the Dominion Experimental Station, Harrow, 1928–1930.

TABLE 1.—SUMMARY OF RESULTS OF EXPERIMENTS SHOWING THE RESPONSE OF FLUE-CURED TOBACCO TO NITROGEN

Quantity of nitrogen per acre lb.	Acre yield lb.	Grade Index ¢
A. Sandy Loam Soil (Harrow, 1930–1935)		
12	997	14.6
24	1067	10.6
32	1119	10.8
40	1103	9.1
B. Light Sandy Loam Soil (Harrow, 1930–1935)		
12	1271	21.4
24	1379	21.4
32	1387	19.0
40	1400	15.6
C. Fox Coarse Sand (Delhi, 1932–1935)		
10	1010	23.4
20	1070	22.2
30	1120	20.6

TABLE 2.—SUMMARY OF RESULTS OF EXPERIMENTS SHOWING THE RESPONSE OF BURLEY AND DARK TOBACCOS TO NITROGEN

Quantity of nitrogen per acre lb.	Acre Yield lb.	Grade Index ¢
A. Burley Tobacco (Sandy Loam Soil, Harrow, 1930–1935)		
40	1357	16.8
60	1462	17.1
80	1454	16.9
100	1492	16.3
B. Dark Tobacco (Silty Loam Soil Harrow, 1930–1935)		
40	919	14.4
60	1065	17.1
80	1332	18.2
100	1234	16.8

TABLE 3.—SUMMARY OF RESULTS OF EXPERIMENTS SHOWING THE RESPONSE OF FLUE-CURED TOBACCO TO PHOSPHORIC ACID

Quantity of phosphoric acid per acre lb.	Acre Yield lb.	Grade Index ¢
A. Fox Coarse Sand (Delhi, 1933–1935)		
40	1130	19.3
100	1140	19.8
160	1080	21.2

TABLE 4.—SUMMARY OF RESULTS OF EXPERIMENTS SHOWING THE RESPONSE OF BURLEY AND DARK TOBACCOS TO PHOSPHORIC ACID

Quantity of phosphoric acid per acre lb.	Acre Yield lb.	Grade Index ¢
A. Burley Tobacco (Sandy Loam Soil, Harrow, 1929–1932)		
0	1131	13.5
40	1364	15.8
80	1492	16.2
100	1481	16.2
B. Burley Tobacco (Clay Loam Soil, Woodslee, 1929–1932)		
40	1397	16.6
80	1411	18.2
160	1502	18.9
C. Dark Tobacco (Light Silty Loam Soil Harrow, 1929–1931)		
0	1125	15.9
40	1184	17.0
80	1235	17.8
160	1272	18.3

TABLE 5.—SUMMARY OF RESULTS OF EXPERIMENTS SHOWING THE RESPONSE OF FLUE-CURED, BURLEY, AND DARK TOBACCOS TO POTASH

Quantity of potash per acre lb.	Acre yield lb.	Grade Index ¢
A. Flue-cured Tobacco (Sandy Loam Soil, Harrow, 1930–1935)		
0	1096	15.0
48	1199	17.0
96	1259	19.0
B. Flue-cured Tobacco (Fox Coarse Sand, Delhi, 1932–1935)		
30	1010	19.5
60	1090	21.7
120	1220	24.6
C. Burley Tobacco (Sandy Loam Soil, Harrow, 1929–1932)		
0	1313	12.3
60	1432	15.0
120	1470	15.6
240	1528	17.8
D. Dark Tobacco (Silty Loam Soil, Harrow, 1929–1931)		
0	1223	14.7
60	1168	14.9
120	1239	17.7
240	1275	16.7

form. The question arises as to whether the improvement in quality resulted because the higher proportion of organic nitrogen furnished the nutrient in a more desirable form, or because a smaller total amount of nitrogen was actually available to the plant. This problem is receiving a more comprehensive study during 1936.

A similar test comparing different nitrogen levels was applied to burley and dark tobaccos. The nitrogen levels in the basal formula for both types of tobacco were set at 40, 60, 80, and 100 pounds per acre. Table 2 shows the response of burley tobacco to nitrogen in the fertilizer. Although the soil on which the burley tests were conducted was thought to be rather low in fertility, it gave less response to nitrogen than expected. The increase in both yield and quality was much more marked with dark tobacco. Although the results show that more than 40 pounds of nitrogen in the fertilizer will benefit the yield and quality of both burley and dark tobaccos under certain conditions, recent tests show that 40 pounds of nitrogen is sufficient where barnyard manure and sweet clover or alfalfa furnish some plant-food and a liberal supply of organic matter. During the final year of the tests with burley tobacco, barnyard manure was applied to two replications of the nitrogen series, and the test demonstrated to some extent that the response from commercial nitrogen on burley tobacco is more marked when applied in conjunction with barnyard manure.

The effects on quality of an excess of nitrogen in the fertilizer formula were less pronounced on burley and dark tobaccos than on the flue-cured type. Nevertheless, too much nitrogen tended to delay maturity, and produced a coarse red leaf in the case of burley, and a slaty green leaf in dark tobacco. Lack of nitrogen lowered the yield and produced a thin papery leaf thereby reducing the quality.

Responses from Phosphoric Acid

Various levels of phosphoric acid were compared in the basal formula for flue-cured tobacco. The response was not pronounced, as outlined in Table 3. Eighty to 100 pounds of phosphoric acid appeared to satisfy the requirements for both yield and quality. A reduced quantity lowered the yield, delayed maturity, and lowered the grade index. On the other hand, excessive applications of phosphoric acid in the fertilizer forced maturity, producing a brittle leaf with prominent veins, though bright in colour. A slight reduction in yield of flue-cured tobacco occurred at Delhi from the application of excessive quantities of phosphoric acid.

The response from phosphoric acid was clearly demonstrated on burley and dark tobaccos as summarized in Table 4. This response was even more pronounced on the heavy soils, particularly the clay loams. The results on burley tobacco indicate that at least 80 pounds of phosphoric acid should be applied on sandy-loam soils for optimum yield and quality. Experiments on the clay-loam soils, however, show that a slightly higher application is required, particularly where barnyard manure and clover are ploughed under. On the other hand, particularly where a dark brown colour is desired in the cured leaf of dark tobacco, it has not been advisable to use more than 80 pounds of phosphoric acid per acre. Heavier applications not only forced maturity but tended to redden the leaf and develop light-coloured, prominent veins and midrib, which is objectionable to the

trade. A quantity of less than 80 pounds had its detrimental effects in lowering both yield and grade index. Therefore, the proper adjustment of this plant nutrient in the fertilizer mixture is of vital importance to the quality of dark tobacco.

Responses from Potash.

The tobacco plant responds more consistently to potash than to any other single element supplied in commercial fertilizers. When potash was applied at various levels in the formula, a practically perfect trend upward in both yield and grade index is pictured in the results on flue-cured tobacco in Table 5. Potash renders the leaf smooth, improves its handling qualities, and makes it more easily cured. Extremely high applications of potash sometimes retard maturity of the leaf, and this factor may limit the extent to which it is advisable to increase the potash application. A deficiency of potash can be readily detected in tobacco both under field conditions and after the tobacco is cured. When such a condition occurs, the quality of the cured leaf is seriously impaired. The results at Harrow and Delhi show the value of liberal applications of potash for flue-cured tobacco. Experiments conducted in the various districts also indicated that at least 80 pounds of potash are required per acre to obtain maximum quality of flue-cured tobacco under most conditions.

A similar trend, but to a lesser extent, is noted in the effect of potash on burley and dark tobaccos. As much as 240 pounds of potash was applied per acre to burley tobacco with no detrimental effect on leaf qualities. One hundred pounds per acre, however, is the quantity now recommended for the sandy-loam soils and 60 pounds for the heavy or clay-loam soils. The maximum quantity that can be used safely for dark tobacco depends on the soil, the crop rotation practised, and the quantity of barnyard manure applied. Where heavy manuring is practised, 60 pounds of potash per acre in the commercial fertilizer appears to be adequate.

Balance of the Plant-Food Nutrients

The preceding paragraphs have dealt wholly with the quantitative effects of the three major elements. Each of these elements has been responsible either for maturity, yield, or the quality of tobacco. It has been demonstrated as a result of these experiments that not only is the quantity of each of these three elements in the fertilizer mixture highly important, but also the ratio of one element to the remaining two has been found to be equally important. In other words, a balance of the nutrients is necessary before optimum results can be obtained.

Fertilizer formulae that appear properly balanced for the three types of tobacco in southwestern Ontario are as follows: for flue-cured, 2% nitrogen, 10% phosphoric acid, and 8% potash; for burley on sandy-loam soils, 4% nitrogen, 8% phosphoric acid, and 10% potash; for burley on clay-loam soils, 2% nitrogen, 12% phosphoric acid, and 6% potash; and for dark tobacco, 4% nitrogen, 8% phosphoric acid, and 6% potash. Nevertheless, a deviation from the ratios outlined above has been found to be necessary where special soil conditions occur.

SUMMARY

(1) Nitrogen was found to be essential for normal growth, but when applied in excessive quantities resulted invariably in delayed maturity and a thicker leaf, thereby interfering with a normal cure. The effect was more exaggerated on flue-cured than on burley or dark tobaccos. Insufficient applications of nitrogen were found to reduce the yield.

(2) Phosphoric acid was found to be essential for normal maturity. Excessive applications forced maturity, accentuated vein structure, and produced a coarsely-grained leaf. Heavy applications produced a bright colour in flue-cured, but impaired the colour of dark tobacco. On the other hand, light applications delayed maturity thus impairing quality in all three types.

(3) Potash was found to be the most important single fertilizer constituent affecting the quality of tobacco, particularly the texture. Excessive applications delayed maturity, while insufficient applications impaired the quality and also reduced the yield considerably on all three types.

(4) These experiments have proved that the proper balance of the three major elements (nitrogen, phosphoric acid, and potash) is of equal importance to the actual quantity of each element applied. The results of these experiments indicate that under average conditions a 2-10-8 mixture is most satisfactory for flue-cured, a 4-8-10 or a 2-12-6 (depending on soil type) for burley, and a 4-8-6 for dark tobacco.

Résumé

L'action des engrais chimiques sur le tabac dans le sud-ouest de l'Ontario. R. J. Haslam et H. F. Murwin, station expérimentale fédérale, Harrow, Ontario.

Il s'est conduit des essais d'engrais chimiques sur les tabacs jaune, burley et foncé pendant une série d'années, sur différents types de sols. Les engrais appliqués à chaque espèce de tabac contenaient différentes quantités d'azote, d'acide phosphorique et de potasse. Le rendement augmentait lorsque l'on appliquait des quantités excessives d'azote, mais la maturité était retardée et la feuille séchée n'était pas d'aussi bonne qualité; il y a eu diminution de rendement lorsque la quantité d'azote fournie était insuffisante. D'autres part, les applications excessives d'acide phosphorique stimulaient la maturité et accentuaient la structure des veines; de faibles applications ont retardé la maturité et détérioré la qualité. On a constaté que le bon équilibre de ces trois éléments principaux était d'importance égale à la quantité de chaque élément appliqué.

SOME OBSERVATIONS ON INDIVIDUAL ASPARAGUS PLANT RECORDS[1]

O. J. Robb[2]

Ontario Horticultural Experiment Station, Vineland Station, Ont.

The wide variation in vigor of growth as well as many other characters found in seedling asparagus plants is a serious handicap to maximum production. This is not fully appreciated by the average grower.

Many varieties have been listed in the past but there is no method of identifying any of them and one can only separate the white or light colored strains from the green. Until the advent of the Washington varieties introduced by the U.S. Department of Agriculture in 1922 asparagus seed usually consisted of several varieties or types. The Mary Washington strain, as introduced, carried a much higher standard of uniformity as well as more vigor. The Martha Washington was smaller but was uniform as to type and carried considerable resistance to the rust disease (*Puccinia asparagi*). It was to overcome rust injury that the breeding work was started which finally produced the Mary Washington variety. This variety now comprises over ninety percent of all commercial plantings in Ontario.

Since the asparagus plant possesses the unusual characteristic of producing staminate and pistillate blossoms on separate plants (7) and in addition to this does not propagate readily by asexual methods, it is next to impossible to secure a large population of uniform plants. Rigorous selection is commonly recommended of the young seedling plants before setting in the permanent bed but it appears to be very difficult to weed out all the undesirable plants at that time (6, 3).

It has been established at this station and also by a number of investigators (1, 2, 5, 8) that the average yields of male or staminate plants are greater than female or pistillate plants. It is necessary to wait until the seedling plant is two years old at least to be able to identify male and female plants, and some would be missed at this time. As it is the usual and recommended practice to plant one-year-old plants the selection of all male plants is not practical. It has been shown that large plants give slightly better yields than unselected plants and that larger plants are less liable to die following planting (3). As no plant characters indicating high yield are known, the best selection method is to pick the largest plants—those possessing large roots and a good number of large buds.

Even with careful work along this line a great deal of variation was found at this station from a series of individual plant records taken on plants picked at random in a mature plot of Mary Washington. The records from three separate series of plants showed a range of four marketable sprouts per plant per season up to forty sprouts. This at once indicates the possibilities of selection if certain of identifying the good plants at planting time. The percentage of low yielding plants is a convincing

[1] Read before a meeting of the Horticultural Group of the C.S.T.A. at the University of New Brunswick, Fredericton, N.B., July 14–15, 1936.

[2] Vegetable Specialist.

argument in favor of a more certain means of selection. Counting all plants with less than ten sprouts per season as unprofitable, it was found that 39% were being grown at a loss. This was the average for three seasons. Our records also show that certain plants were low in yield each season and some other plants were high each season. It was suggested to the author that earliness of yield might be a factor worth considering. An analysis of the early season yields indicated much the same variation as the yields for the whole season, in fact, with minor fluctuations, the individual plants with high yields for the whole season were also the high early producing plants. In all three series it was found that there was a high positive coefficient of correlation between early yields* and total yields† (Table 1).

TABLE 1.—COEFFICIENT OF CORRELATION BETWEEN EARLY AND TOTAL YIELDS OF SPROUTS OF INDIVIDUAL ASPARAGUS PLANTS

Series	Years	Coefficient of correlation
No. 1.	1926–28	+.89 ±.02
No. 2.	1930–32	+.618 ±.072
No. 3.	1930–32	+.911 ±.018

* Early yields in all cases were less than one-third of the total yield.
† Yields refer to number of marketable sprouts.

These individual plant yield records indicated such a wide variation that it was decided to undertake some selection of parent plants. Consequently several high yielding female plants were crossed with high yielding male plants, the seed was harvested and the resulting seedlings were set out in a comprehensive experimental plot in the spring of 1935. Plants obtained from commercial seed were also included in this experiment. Yield records will be taken on these plots beginning in 1937.

REFERENCES

1. HABER, E. S. Jour. Agri. Research, Vol. 45 : No. 2 : 101-106. 1932.
2. HANNA, G. C. Proc. Amer. Soc. Hort. Sc. Vol. 33 : 493. 1934.
3. MYERS, C. E. Ann. Report Penn. State College, 563-576. 1915–16.
4. NORTON, J. B. Mkt. Grs. Jnl. 229-232. March 15, 1924.
5. RAWES, A. N. Jour. of Royal Hort. Soc. Vol. 60, Part 10 : 452-453. 1935.
6. TIEDJENS, V. A. Proc. Amer. Soc. Hort. Sc. Vol. 25 : 37-40. 1928.
7. SCHERMERHORN, L. G. Proc. Amer. Soc. Hort. Sc. Vol. 25 : 35-36. 1928.
8. ———. Report of the Minister of Agric. for Ont. 56-62. 1927.

Résumé

Quelques observations sur la production des pieds d'asperges. O. J. Robb, Station horticole expérimentale d'Ontario, Vineland, Ontario.

A la station expérimentale d'horticulture d'Ontario, des notes prises sur la production d'asperges ont révélé de grandes différences entre les pieds : la quantité de pointes marchandes par pied variait de 4 à 40 pour la saison et 39% du nombre total de pieds ont produit moins de dix pointes. Il y avait un fort coefficient positif de corrélation entre les rendements précoces et les rendements totaux, indiquant que les rendements notés au début de la saison peuvent servir de guide dans la recherche des pieds à gros rendement. On compare actuellement la progéniture de parents à gros rendement avec des pieds d'origine commerciale dans un essai en pleine terre.

PROPAGATION RESPONSE FROM ROOT CUTTINGS PLANTED WITH THE PROXIMAL END PROJECTING ABOVE THE MEDIUM[1]

W. H. Upshall[2]

Ontario Horticultural Experiment Station, Vineland Station, Ont.

In previous investigations by the author (3) root cuttings were usually planted in a vertical position and with the proximal end just submerged. Beginning early in 1933, in a sand-peat medium on a raised greenhouse bench, a few apple root cuttings were planted with the proximal end projecting about 0.6 cm. above the medium. A comparable lot was planted at the same time in the usual way, viz., just submerged. Rooting results were very decidedly in favour of the new method. In the spring of 1934 and the fall of 1935 this test was repeated, using plum and apple variety root cuttings, with similar results. Complete data are given in Table 1. Not only was there a much better rooting response from the cuttings which projected above the medium, but top growth was much more rapid and the cuttings which failed to develop into new plants did not rot as quickly as those which were completely submerged (Figure 1).

Table 1.—Methods of planting apple and plum root cuttings in the greenhouse. Average length of cuttings—6 cms. Depth of medium—15 cms.

Time of planting	Kind	No. under each treatment	% rooted	
			Projecting 0.6–2.5 cms.	Just submerged
Jan. 5, 1933	Apple varieties	73	48.6	6.7
Apr. 3–13, 1934	Apple varieties	85	41.2	16.5
Apr. 13, 1934	Plum varieties	47	23.4	12.8
Oct. 31, 1935	Apple varieties	138	35 1	4.2
Oct. 31, 1935	Plum varieties	62	69.0	6.1

It is a well known fact that roots of fruit trees dry out quite rapidly on exposure to air, very much more quickly than the branches of the top. It was this consideration which, in early experiments deterred the author from planting root cuttings partially above the medium. Now it becomes evident that desiccation of the cuttings on an open greenhouse bench is not to be feared even when they are watered only once a week.

The beneficial effect of planting the root cuttings in this way may be due to the light factor and then again it may involve a water or aeration effect. Stoutemyer and associates (2) have recently reported that "the formation of adventitious buds on the root pieces (apple) occurred most readily when they were exposed freely to light and air in a closed case maintained at a rather high temperature." Hottes (1) gives a list of plants which can best be propagated in the greenhouse from root cuttings when the ends project a half inch However, apple and plum are not among the plants on this list which is made up of fleshy rooted species.

[1] Read before a meeting of the Horticultural Group of the C.S.T.A. at the University of New Brunswick, Fredericton, N.B., July 14–15, 1936.

[2] Research Specialist.

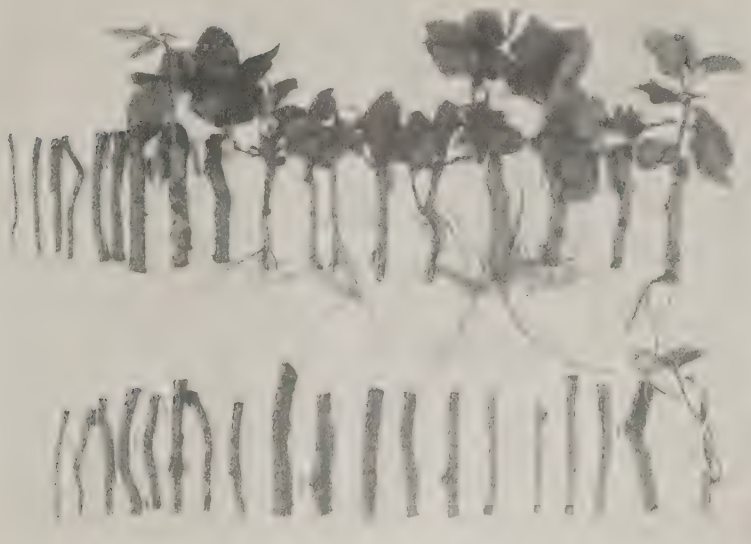

FIGURE 1. Reine Claude root cuttings planted Oct. 31, 1935. Taken up April 1, 1936. Upper row planted with proximal end projecting 0.6 cms. above the medium; lower row, just submerged. All dark coloured roots (left) were rotten when taken up.

Information now at hand gives some encouragement of being able, on further refinement in technique, to increase in a commercial way selected stocks by the root cutting method. In the spring of 1936, for instance, 30 rooted plants were obtained in the greenhouse in two months' time from 35 root cuttings of Malling Mazzard selection F12/1 taken from two-year old plants. These cuttings were planted with the proximal end projecting. Plantings of variety root cuttings in the field have given very poor results. In one test at this station cuttings projecting 1.5 cms. above the ground gave no better results than those which were submerged and both were nearly a total failure. Had irrigation been available the results might have been more satisfactory.

REFERENCES

1. HOTTES, A. C. Plant Propagation. A. T. De La Mare Co., New York. 1934.
2. STOUTEMYER, V. T. *et al.* Some observations on the production of own rooted apple stocks from root cuttings. Proc. Amer. Soc. Hort. Sc. 33 : 350-354. 1935.
3. UPSHALL, W. H. The propagation of apples by means of root cuttings. Sci. Agric. 12 : 1-30. 1931.

Résumé

Comportement des boutures de racines plantées avec le bout proximal faisant saillie au-dessus du milieu de culture. W. H. Upshall, Station d'horticulture expérimentale, Station de Vineland, Ont.

Dans ces essais qui ont duré trois saisons, des boutures de racines de certaines variétés de pommiers et de pruniers, plantées sur une tablette de serre, l'extrémité proximale faisant saillie de 0.6 2.5 cms, ont fait une meilleure pousse et produit une meilleure densité que des boutures semblables complètement recouvertes de terre.

MINOR ELEMENTS AFFECTING HORTICULTURAL CROPS[1]

H. Hill[2]

Central Experimental Farm, Ottawa, Canada

Perhaps one of the most outstanding developments of the last few years in the field of plant nutrition has been the recognition that many elements to which little attention was given a short time ago are essential for the normal growth of plants. Up until this period it was generally recognized that there were ten essential elements, namely; nitrogen, phosphorus, potassium carbon, hydrogen, oxygen, sulphur, magnesium, iron and calcium. Three of these elements, nitrogen, phosphorus and potassium are the ones most likely to be inadequate for satisfactory growth and we have gone so far for practical purposes as to designate a fertilizer containing these three elements as a complete fertilizer and to regard other known essential elements as amendments or correctives. In addition to the ten elements mentioned, the presence of other elements in minute amounts has been detected in various plants but their importance in plant growth and nutrition was not realized. For the sake of convenience and by reason of the relatively small amounts necessary for normal growth these have been called minor elements.

It is only in the last few years that these minor elements have assumed a place of economic importance in the growth of plants. At least two reasons may be suggested why this is so: the first is the considerable replacement of natural manures as a means of added fertility by chemical fertilizers; and the second is the greater purification of these chemical fertilizers in the process of manufacture, and the replacement of naturally derived fertilizers by synthetic ones. Besides supplying the "big ten" elements, manure also contains small amounts of the minor elements, so that when manure was the chief source of added fertility deficiencies of these minor elements did not occur. Chemical fertilizers derived from natural deposits contained these elements as impurities in sufficient amount to meet plant requirements. Thus Chilean or natural nitrate of soda is found to contain some thirty additional elements.

BORON

In 1923 Warington (20) showed that broad beans obtained full development only when a trace of boron was given. The best results were obtained with quantities of the order of one part of H_3BO_3 per million of the culture solution; amounts greater than 1 in 5000 were harmful. Since then, reports of many investigators indicate that boron is essential for a large number of plants in differing amounts and that certain physiological disorders may be due to a deficiency of this element. Sommer and Sorokin (19) studied the effect of the absence of boron on the growth and development of *Pisum sativum* in culture solutions. They found that the meristematic region of root tips grown without boron becomes abnormal. Johnston and

[1] Contribution No. 466 from the Division of Horticulture. Read before a joint session of the Horticultural Group and the Soils Group of the Canadian Society of Technical Agriculturists, and the Canadian Phytopathological Society, at the University of New Brunswick, Fredericton, N.B., July 15, 1936.

[2] Assistant in Horticultural Research.

Dore (13) found that the element boron in a concentration of approximately 0.5 p.p.m. was necessary for the normal growth and development of the tomato. A concentration of 5.5 p.p.m. boron in the nutrient solution was toxic to tomato plants. McHargue and Calfee (18) report that boron is essential for the growth of lettuce and where excluded from the nutrient solution a severe deficiency disease results, characterized by malformation of the rapidly growing leaves and spotting and browning of the leaf tips. The optimum concentration of boron was found to be 0.7 p.p.m. while concentrations from 1.2 to 2.5 p.p.m. produced increasing toxicity. Brandenburg (3) working with sugar beets in sand found that as high as 30 mg. boric acid could be added to ten a litre pot without causing any signs of toxicity due to excess boron, and that even this application gave very weak symptoms of boron deficiency after a prolonged period of growth. Workers in the Irish Free State (12) demonstrated that crown rot of sugar beets in Ireland is associated with a deficiency of boron in the soil and that indirect evidence indicated that in the presence of a high pH, due to overliming or a natural high lime or magnesia content of the soil, boron may be relatively unavailable. McLeod and Howatt (15) have shown that brown heart of turnips is a parallel disorder controlled by the application of ten pounds per acre of boron.

The Division of Horticulture, Ottawa, has carried on studies concerning the effect of the presence or absence of boron in the nutrient solution on the growth of turnips in sand cultures (10). Five different boron treatments were employed, boron being supplied in the form of boric acid.

I. No boron.
II. Boron concentration of solution 0.25 p.p.m.
III. Boron concentration of solution 0.50 p.p.m.
IV. Boron concentration of solution 1.0 p.p.m.
V. Boron concentration of solution 1.5 p.p.m.

After being subjected to these treatments for a period of six weeks, plants receiving no boron showed definite signs of disorder. The injury commenced as a slight yellow marginal colouring of the leaves, in time involving large areas (Figure 1). The region next to the veins remained green the longest. In some cases the undersides of the leaves were markedly reddish-purple. After a period of ten weeks, the leaves were markedly curled, assumed a greyish white scorched appearance and finally died (Figure 2). Leaf petioles had dried up corky growth on the inner edges or severe splitting of the petioles occurred (Figure 3). Root development was interfered with. The roots were small, deformed and shrivelled or rotting at their juncture with the top. Any roots which formed were affected with hollow heart (Figure 4). Plants receiving 0.25 p.p.m. of boron made fairly good growth although many of the leaves were noticeably curled and yellow at the margins with distinct purple pigmentation on the under-surface. A considerable proportion of the older leaves were scorched and dying. Roots were medium in size but were all seriously affected with brown or hollow heart. Plants receiving 0.5 p.p.m. of boron were considerably more vigorous; foliage injury was still evident though reduced greatly in severity. Roots were large in size but were severely affected with hollow or brown heart. Plants receiving 1 and 1.5 p.p.m. of boron

were large and vigorous with very large roots. A small amount of foliage injury still persisted but roots were free from hollow heart. Roots from plants receiving 1 p.p.m. were still somewhat affected with brown heart while in roots receiving 1.5 p.p.m. there was a still further reduction in the severity of the trouble. Twenty per cent of the roots in this treatment were entirely healthy while in the others affected tissue was confined to a small area at the centre or base.

Analytical data revealed a very low ash in dry matter of the roots fed high boron as compared with roots from plants not receiving boron or fed low concentrations. A decided reduction of calcium accumulation was found in the roots when boron was fed. Lack or deficiency of boron caused an accumulation of potassium, phosphorus, magnesium and calcium in the roots.

An attempt was made to ascertain if either copper or zinc could replace boron in the nutrition of the turnip. Plants were grown in sterile sand and provided with nutrient solution lacking boron but containing either zinc or copper. It was found that neither of these elements could replace boron, typical boron deficiency symptoms occurring as a yellowing and purpling of the foliage and hollow hearting of the small sized, badly deformed roots. Observations were also made as to the effect of the presence or absence of boron in the nutrient solution on the growth of the tomato plant in sand cultures. Definite growth disturbances were observed when no boron was supplied. The lower leaves became chlorotic with the veins reddened and prominent. Later the affected foliage became almost orange in colour between the veins (Figure 6). This was followed by a purple spotting or blotching and the death of the lower foliage. The stems and petioles were extremely weak and brittle. Fruits were often shrivelled, exhibiting dark water-soaked like areas which turned to light brown russet or scabby lesions on ripe fruit (Figure 7). One part per million of boron in the nutrient solution produced normal growth.

Although injury to potato crops has been reported from ordinary commercial fertilizers found to contain appreciable amounts of boron (16), plants grown at Ottawa in sand cultures not receiving boron in the nutrient solution exhibited specific growth disorders. Plants were extremely poor in vigor; the margins of the leaves were crinkled, often accompanied by a yellowing or reddening. The yield was greatly reduced, the quality poor, and the tubers scurfy or badly russeted. After cooking, the flesh was slightly yellow.

Workers in New Zealand (2) and the Experimental Station at Summerland, B.C., (6) have reported that injections of boric acid into the tree have brought about control of physiological disorders of apples, such as corky-core and drought spot.

At Ottawa, trees in pots known to be affected with blotchy-cork were divided into two groups. One group was fed a complete nutrient solution containing boron at the rate of 1 p.p.m. in the solution; the other group a nutrient solution from which boron was omitted. Trees not receiving this element continued to be affected with cork, while those receiving it recovered entirely from the disorder. At Brighton, Ontario, limbs of affected trees were injected with 1 gram of boric acid. Untreated limbs

showed 94% of the fruit affected with corky-core while the injected limbs had but 60% of the fruit affected. In connection with the occurrence of cork or corky-core under orchard conditions it is interesting to note that invariably these troubles were associated with an alkaline or high lime condition of the soil.

COPPER

It has been reported that peat soils and mucks are frequently very unproductive without additions of copper. Deficiency is characterized by a yellowing or chlorosis of the leaves. It has been advised (5) that on newly cropped mucks it will be wise to broadcast finely granulated copper sulphate at the rate of 50 lbs. per acre. In Holland it is a recognized practice in reclamation of peat land to add 50 kg. per acre of copper sulphate during the first year. Anderssen (1) reports that 0.25 to 2 lbs. of copper sulphate per tree remedied a chlorotic condition of deciduous fruit trees on a sandy soil of acid reaction. Felix (7) reports that in Western New York there are areas of muck soils unproductive for lettuce and onions unless treated with pulverized copper sulphate at the rate of 100 to 200 lbs. per acre. The practice of spraying or dusting plants with copper compounds for disease control appears to bring about increases in yield not entirely due to the protection provided. At Brighton, Ontario, copper sulphate was injected into limbs of trees affected with corky-core, but these injections had no influence in so far as reducing the severity of the disorder.

We have grown various plants, such as tomatoes, chrysanthemums, strawberries, turnips, etc., in sand cultures, and in no case was it found necessary to supply copper in the nutrient solution. However, this does not necessarily mean that copper is not essential in the nutrition of these plants since very minute amounts may have been available as impurities in the chemicals employed or the plant may have been able to secure sufficient from the glazed pot containers (17). Copper was fed to tomato plants in concentrations ranging from .05 to 1.0 p.p.m. in the nutrient solution. Plants fed the highest concentration were affected by a light yellowish mottling of the upper foliage, otherwise no injury was observed.

MANGANESE

Manganese deficiency brings about a condition of chlorosis indeterminable from a lime induced or iron deficiency chlorosis. It is more apt to occur on alkaline soils (14), so that limed soils with a neutral to alkaline reaction may be affected with manganese deficiency owing to lack of availability. It is of interest to note that in an area at Ottawa nursery apple trees were severely chlorotic, and a strawberry plantation was markedly lacking in vigor with slight yellowing of the foliage. It was found that the soil was decidedly alkaline having a pH of 8.0. The effect of adding manganese to the soil was tested by adding .004 grams of manganous sulphate to each 5″ pot of soil in which strawberry plants were grown. Healthy vigorous plants were secured in comparison with low vigor, poor colored foliage plants of the checks.

Gilbert and McLean (9) report increased yields of tilled crops of corn, lettuce, onions and mangels by applications of manganous sulphate, and

elimination of chlorosis of spinach on heavily limed soils by the application of 8 lbs. of manganous sulphate per acre. Hoffman (11) has reported manganese as necessary for the proper growth of tomatoes. The first effects of deficiency are the changing from green to yellow of the web of the leaf, the veins remaining green, producing a mottled effect. The blossom buds turn yellow and fall before opening.

Studies conducted at the Horticultural Division, Ottawa, with the potato plant by means of sand cultures revealed that manganese is essential for the normal development of this plant. In the absence of manganese the plants were stunted with shortened petioles and the foliage was light green with the older leaves yellowing between the veins and noticeably curled. The yield was greatly reduced with the tubers badly russeted and having enlarged lenticels.

ZINC

It has been reported that zinc sulphate is effective in controlling little leaf or rosette of fruit trees (4), pecan rosette (8), and bronzing of tung-oil trees. Rosette is a condition found in stone fruits, apples, pecans, walnuts and citrus fruits. The symptoms are a yellow mottling of the leaves which become rough and crinkled, causing the veins to stand out. The chlorotic areas sometimes turn a dark reddish brown in later stages of the disease and the leaves cluster together like rosettes.

We have fed zinc to tomato plants at concentrations ranging from .01 to .5 p.p.m. in the nutrient solution without observing either signs of injury or stimulation. Uranium and strontium have been employed at the same concentrations without outward results.

CONCLUSION

There is considerable evidence to indicate that small quantities of boron and manganese are essential to the normal development of many plants. Copper and zinc have been found to be specific remedies for certain physiological disorders though there appears to be no definite proof of their universal need.

REFERENCES

1. Anderssen, F. G. Chlorosis of deciduous fruit trees due to a copper deficiency. Jour. Pomol. Hort. Sci. 10 : 130-143.

2. Atkinson, J. D. Progress report on the investigation of corky-pit of apples. New Zealand Jour. of Sci. and Technology, 16 : 3. 1935.

3. Brandenburg, E. Die Herz und Trockenfäule der Rüben Ursache und Bekämfung. Augewandte Botanik, 14 : 194-228.

4. Chandler, W. H., Hoagland, D. R. and Hibbard, P. L. Little leaf or rosette of fruit trees—II. Effect of zinc and other treatments. Amer. Soc. of Hort. Sci. Proc. 28 : 255-263. 1932.

5. Conner, S. D. Treatment of muck and dark sandy soils. Ind. Agr. Extension Service Leaflet No. 179. 1933.

6. Dominion Experimental Station, Summerland, B.C. Leaflet 860M. Boron injections as a remedy for drought spot and corky core.

7. Felix, E. L. Correction of unproductive muck by the addition of copper. Phytopath. 17 : 49-50.

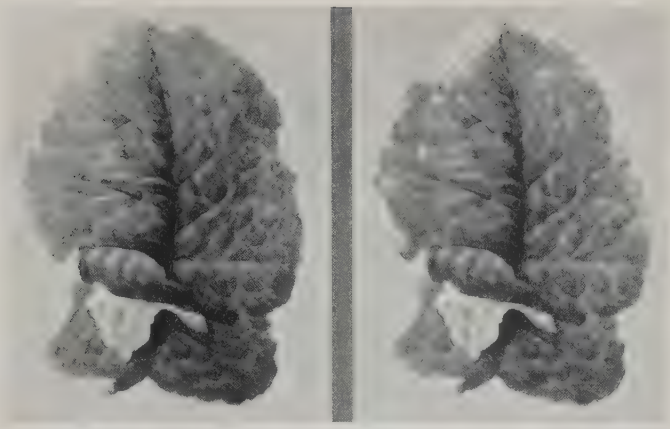

FIGURE 1. *Left:* Leaf from plant receiving 1.5 p.p.m. boron—normal appearance. *Right:* Leaf from plant lacking boron, showing marginal yellowing in the initial stages of boron deficiency.

FIGURE 2. Plant grown with lacking boron solution—Note scorching of the leaves.

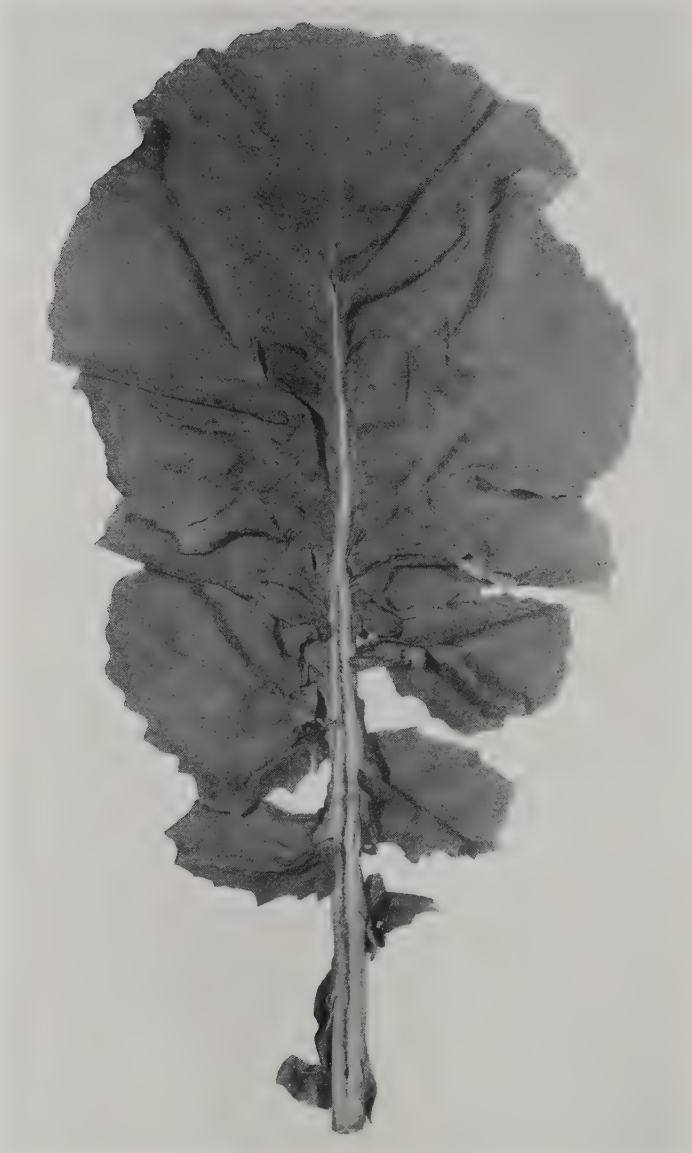

FIGURE 3. Splitting of the leaf petiole due to a lack of boron in the nutrient solution.

FIGURE 4. Showing cross section of roots produced under the different boron concentrations.

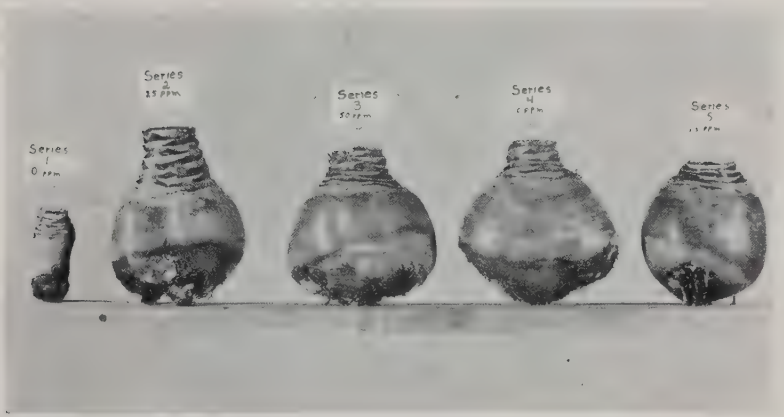

FIGURE 5. Showing root development under the range of boron concentrations employed.

FIGURE 6. Leaves from tomato plants grown in sand cultures not receiving boron.

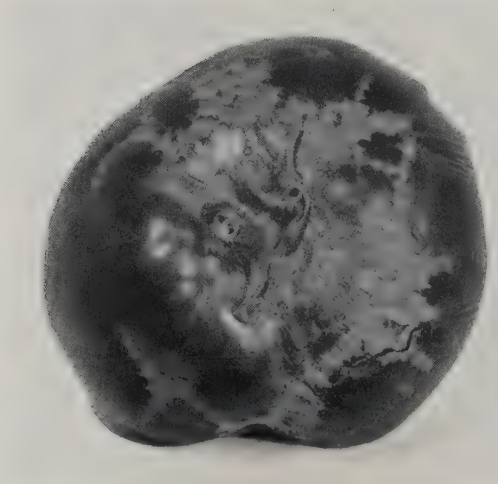

FIGURE 7. Effect of boron deficiency on the tomato.

8. Finch, A. H. Pecan rosette—a physiological disease apparently susceptible to treatment with zinc. Amer. Soc. Hort. Sci. Proc. 29 : 264-266. 1932.

9. Gilbert, B. E., and McLean, F. T. "A deficiency disease." The lack of available manganese in a lime-induced chlorosis. Soil Sci. 26 : 1. 1928.

10. Hill, H. and Grant, E. P. The growth of turnips in artificial cultures. Sci. Agr. 15 : 9. 1935.

11. Hoffman, I. C. Mineral deficiency symptoms in tomato and cucumber plants. Ohio Vegetable Growers' Assoc. Proc. 18th Ann. Meeting. 1933.

12. Irish Free State. Crown rot of sugar beet, boron trials. Jealott's Hill Agr. Res Bull. 4 : No. 4. April, 1935.

13. Johnston, Earl S., and Dore, W. H. The influence of boron on the chemical composition and growth of the tomato plant. Plant Phy. 4 : 31-62. 1929.

14. Leeper, G. W. Relationship of soils to manganese deficiency of plants. Nature, 134 : 972-973. 1934.

15. MacLeod, D. J. and Howatt, J. L. Soil treatment in the control of certain soil borne diseases of potatoes. Amer. Potato Jour. 11 : 60-61. 1934.

16. Moore, W. J. Some observations upon the effect of borax in fertilizers. Maine Sta. Bul. 288 : 89-120. 1920.

17. McHargue, J. S. Common earthenware jars as a source of error in pot Experiments. Jour. Agr. Res. 26 : 5. 1923.

18. McHargue, J. S. and Calfee, R. K. Further evidence that boron is essential for the growth of lettuce. Plant Phy. 8 : 305-313. 1933.

19. Sommer, A. L. and Sorokin, Helen. Effects of the absence of boron and of some other essential elements on the cell and tissue structure of the root tips of *Pisum sativum*. Plant Phy. 3 : 237-254. 1928.

20. Warington, K. The effect of boric acid and borax on the broad bean and certain other plants. Ann. Bot. 37 : 629-672. 1923.

Résumé

Éléments secondaires qui affectent les plantes horticoles, par H. Hill, Ferme expérimentale centrale, Ottawa, Ont.

Il existe de nombreuses preuves indiquant que de petites quantité de bore et de manganèse sont essentielles au développement normal d'un grand nombre de plantes. On a constaté également que le cuivre et le zinc sont des remèdes spécifiques pour certains troubles physiologiques, mais il ne paraît pas y avoir de preuve précise indiquant qu'ils soient nécessaires en toute circonstance.

26664—4 E

THE ECONOMIC SITUATION[1]

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH,
DEPARTMENT OF AGRICULTURE, OTTAWA,
FROM BASIC DATA COLLECTED BY THE
DOMINION BUREAU OF STATISTICS

General business conditions showed considerable improvement during the first nine months of the year over the corresponding period of 1935. The nine month averages of the various index numbers quoted in the Annalist, as computed by the Dominion Bureau of Statistics, registered substantial gains. The physical volume of business index increased by 8 percent, that of industrial production by 8½ percent and the agricultural marketings index by 10 percent. Price index numbers showed modest gains; the wholesale index and the retail index each advanced by 2 percent, while the index of farm products rose by 7½ percent. The period was one of slow but steady general economic progress and the last two months in particular marked a much needed increase in the purchasing power of the farmer, through the rise in the value of farm products.

Physical Volume of Business.—During the months of August and September business continued to record further gains. The slight decline in the physical volume of business shown in the index figure for July, was offset in August by a gain of 3 percent to 113.2 and a further gain in the September index over that of August of 1.8 percent making the index 115.3. The index of industrial production gained 6.5 points in the two months. Mineral production increased at about the same rate as manufacturing, and the construction index which declined in August, regained the loss during September and was slightly better than the figure for July. The monthly output of electric power declined slightly during both months, and the distribution index showed a gain of 1.7 points; trade employment, and import and export indexes improved but carloadings declined The index of agricultural marketings, influenced by the heavy wheat shipments during August, fluctuated considerably; the figure for July was 103.9, August 216.9 and September 162.6. The index of livestock marketings declined in August but rose substantially in September to 103.5, while the grain marketings index which stood at 246.1 in August—an increase of 134 percent over the figure for July, dropped back during September to 175.8.

Wholesale Prices.—Commodity markets remained stable during September and the general price index, which touched 76.6 for the week ended 25th, was 76.4 for the month. Markets were stronger during October although there was a slight recession toward the close of the month. The monthly index was 77.1 marking a a new high point in the economic recovery. Grain prices continue to play a prominent part in influencing index fluctuations.

Retail Prices.—During September a slight increase occurred in the retail price index due chiefly to a rise in the prices of bacon, eggs, butter, cheese, dry beans and to a lesser extent in prices for flour, bread, cooked hams and canned vegetables. Easier prices for creamery butter, potatoes, onions and meat during October were sufficient however to offset a seasonal advance in the fuel index and also to counteract minor increases in the clothing and rent indexes.

Prices of Farm Products.—Wheat prices held the gains recorded in the first two weeks of September and advanced further up to the 24th, when No. 1 Northern cash wheat closed at $1.11⅜. Indefinite market reports checked overseas buying during the last week of the month and cash wheat was quoted on September 30th at $1.06⅞. The average monthly price for No. 1 Northern cash wheat was 103.9

[1] Prepared for publication in the Economic Annalist.

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION
COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913	64.0	62.6	56.4	77.0	65.4				
1914	65.5	69.2	64.9	79.0	66.0				
1915	70.4	77.7	76.9	79.2	67.3				
1916	84.3	89.7	88.4	92.3	72.5				
1917	114.3	130.0	134.3	119.6	85.6				
1918	127.4	132.9	132.0	134.7	97.4				
1919	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.8
1923	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.6
1924	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.9
1925	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.6
1926	100.0	100.0	100.0	100 0	100 0	100.0	100.0	100.0	100 0
1927	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933	67.1	51.0	45.8	59.7	77.7	79.7	76.8	105.1	115.4
1934	71.6	59.0	53.8	67.7	78.9	94.2	93.6	88.5	114.2
1935	72.1	63.4	57.1	73.9	79.3	102.4	103.3	87.4	128.4
1935									
July	71 5	61.5	55.7	71 1	78 8	103.0	104 0	164.7	114.8
Aug.	71 6	61.8	55.5	72.4	79 4	107.9	110.3	163.9	117.0
Sept.	72.3	64.7	58.3	76 5	79 6	101.9	102.5	114 2	117.2
Oct.	73.1	65.8	59.3	76.7	80.3	107.2	109 5	86.6	119.7
Nov.	72.7	65.0	57.8	77.1	80.6	110.0	113.5	43.3	127.1
Dec.	72.6	65.4	57.9	77.9	80.5	106.2	108.8	34.0	133.4
1936									
Jan.	72.9	65.9	59.0	77.5	80.5	105.2	107.0	39.8	143.4
Feb.	72.5	66.0	58.9	77.8	80 3	104.9	104.9	62.7	150.3
Mar.	72.4	65.5	59.2	76 0	80.4	103.3	104.1	89.5	149.5
Apr.	72.2	65.0	59 8	73.8	79 7	108 8	109.2	115.8	149.3
May	71.8	64.8	59.9	73 0	80.0	109 7	110.6	110.0	144.5
June	72.3	64.5	60.8	70.7	80.1	110.3	111.6	73 6	171.9
July	74.4	66.3	63.2	71.6	80 4	110.0	111.1	103.9	137.5
Aug.	76.2	73.3	74.1	71.9	81.0	113.2	115 2	216.9	129.7
Sept.	76.4	74.4	74.2	74.7	81.5	115.3	117.6	162.6	130.0
Oct.	77.1	76.3	76.4	76.2	81.5	119.8	123.8	71.6	146.3

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1934, p. 15.
2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1934, p 52, and Monthly Mimeographs 1934 and 1935.
3. Wholesale prices of grains, fruits and vegetables.
4. Wholesale prices of Animals and Animal Products.
5. Including foods, rents, fuel clothing and sundries. See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.
Prices and Price Indexes 1913-1934, p. 117, and Monthly Mimeographs, 1934-1935.
6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical Volume of Business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

cents a bushel compared with 90 3 cents in September of 1935 and 102.2 cents for August of this year The threatening drought situation in Australia stimulated export demand during the first two weeks of October and No. 1 Northern cash wheat closed at $1.14⅞ on the 14th, but in the reaction which followed lost nearly 6 cents a bushel, and closed at the end of the month at $1.08⅛. The average price for the

month of October was 110.9 cents a bushel compared with 90.8 cents in October of 1935. Other grains, with the exception of rye, averaged lower during September and October than in August.

Markets for good quality cattle were active and strong throughout September and the first two weeks of October. Record runs for the current year were experienced at some yards during mid-September and early October. Average prices during September for steers and calves advanced over the figure for August, but those of bacon hogs declined. October prices were generally easier; calves and lambs held steady, and hog prices recorded a further decline following the receipt of cables indicating probable reductions in United Kingdom bacon quotations.

Butter prices declined during the early part of September, but thereafter quotations held comparatively firm easing slightly during October. Export demand was slight. Average prices were fractionally lower during September while a decline of about 1 cent a pound was recorded during October. Egg markets showed appreciable gains during September and a marked scarcity of fresh supplies during October caused firmer prices. Average prices during October for Grade A. large were: Montreal 46.4 cents per dozen, Toronto 44.5 cents and Vancouver 38.5 cents.

Prices in the United Kingdom.—As the index of prices of agricultural produce for the year ended August 1936 is now available, it seems opportune to review the situation in the United Kingdom during recent years.

During the last six years the general index of agricultural produce (base 1911–1913 = 100) dropped from 125 in 1930–31 to a low point of 106 for the year ended August 1933. The following three years all showed improvement and in 1936 the index stood at 120. If allowance is made for "deficiency payments" under the Wheat Act, 1932 and the subsidy under the Cattle Industry Act, 1934, the index for 1933 would be 110 and for 1936, 125. The rise in the index for the year (September-August) 1936 over the similar period of the preceding year was 5 points, or allowing for the "deficiency payments" and the cattle subsidy in both years, 4 points. The upward movement was due chiefly to increases in the average prices of wheat, fat cattle, milk, butter, cheese, eggs, potatoes, fruit, vegetables and wool; which more than offset the effect of reduced prices for oats, fat sheep, pork pigs and hay. Average prices of barley, bacon pigs and hops showed little change during the two years.

The following table shows the general index numbers of prices of agricultural produce (September-August) 1930–31 to 1935–36, on the base 1911–13 = 100.

1930–31	1931–32	1932–33	1933–34	1934–35	1935–36
125	114	106	113	115	120
		110	117	121	125

The second line shows the index numbers after allowance is made for payments under the Wheat Act 1932 and the Cattle Industry (Emergency Provisions) Act, 1934.

The September 1936 index of agricultural produce at 127 showed a gain of 8 points over that of August and was 6 points above the corresponding figure of a year ago. Adjusted for payments under the Wheat and Cattle Industry Acts the index for September is 133. The rise in the index is attributable very largely to the higher prices of milk, potatoes and barley, and to a lesser extent, fat sheep and hay. Average prices of wheat, oats and fat cattle were lower than in August.

The Situation in the United States.—The general index of farm prices (August 1909–July 1914 = 100) for October was 121—the index for January of the current year was 109. The preliminary index (1910–14 = 100) of prices paid by farmers for commodities was 127 for October. The Department of Labour retail food price index (1910–14 = 100) for September was 138 and the wholesale price index stood at 119.

LAND UTILIZATION IN SOUTHWEST CENTRAL SASKATCHEWAN

C. C. SPENCE[1]

In 1935 an economic survey was made in Rural Municipalities of Waverley No. 44, Wood River No. 74, Gravelbourg, No. 104, Glen Bain No. 105, Shamrock No. 134, Chaplin No. 164 and tps. 7 and 8, rge. 7 of Pinto Creek No. 75, in southwest central Saskatchewan to determine an economic classification of the land based on the physical and financial evidence of progress made by the settlers in the use of the land.[2] Eight hundred and thirty-six farmers co-operated in providing pertinent information concerning the history and present status of their farm business since commencing on the farms which they occupied at the time of the survey. The farms, approximately thirty percent of the total number occupied in the area of the survey, were selected at random and are considered representative of a large part of southern Saskatchewan which has suffered from drought since 1928. The area lies in the semi-arid short grass plains belt, and the topography varies from broad level plains to hilly, and includes eroded sections. The soil ranges from the least to about the most productive in the province. The present use of the land and the changes which have taken place since settlement are described in this article.[3]

Use of Land by Municipalities.—The average area of the farms in the survey was 542 acres. The average of all farms in Saskatchewan in 1931 according to the Dominion Census was 408 acres. The municipality of Gravelbourg showed the largest average farm area, and Waverley the smallest, but in all municipalities the average size exceeded three-quarters of a section.

TABLE 1.—USE OF LAND IN FARMS—AVERAGED BY MUNICIPALITIES—FOR 836 FARMS, ECONOMIC SURVEY, SOUTHWEST CENTRAL SASKATCHEWAN 1935

	All municipalities	Waverley No. 44	Wood River No. 74	Pinto Creek No. 75[1]	Gravelbourg No. 104	Glen Bain No. 105	Shamrock No. 134	Chaplin No. 164
Number of farms	836	143	152	21	146	138	122	114
	ac.	ac.	ac.	ac.	ac.	ac.	ac.	ac.
Average per farm	542	494	506	629	583	557	540	566
Cropland including fallow and breaking	429	343	451	494	515	490	418	323
Unimproved and farmstead	113	151	55	135	68	67	122	243
Wheat	176	119	198	137	246	215	165	102
Oats	42	34	43	45	45	41	47	44
Rye	8	5	1	18	2	1	14	30
Barley	3	2	1	4	3	4	1	7
Flax	1	—	1	—	—	1	—	—
Forage crops	1	1	—	1	1	1	2	2
Other crops	1	1	—	1	—	—	1	1
Fallow and breaking	152	121	180	133	197	186	128	85
Idle improved	45	60	27	155	21	41	60	52

[1] Two townships only (Tps. 7 and 8, rge. 7, W. 3rd mer.).

About ninety percent of the land on the farms in the municipalities of Wood River, Gravelbourg and Glen Bain is improved, but less than 60 percent in the municipality of Chaplin, while the average for all municipalities is approximately 80 percent.

[1] Field Assistant, Economics Branch, Department of Agriculture, Ottawa.

[2] Conducted by the Department of Farm Management, University of Saskatchewan, in co-operation with the Economics Branch of the Dominion Department of Agriculture with funds largely supplied by the Saskatchewan Agricultural Research Foundation, the Saskatchewan Department of Agriculture and the Prairie Farm Rehabilitation Committee.

[3] The present article is a brief sketch written from the data assembled which will be made available at a later date, and is a preliminary statement subject to revision and correction.

In 1935 the acreage sown to wheat averaged 41 percent of the cropland for all farms surveyed in the seven municipalities; the smallest acreage of wheat being in Chaplin, where a larger acreage of rye was sown than in the other municipalities. Little difference in the average acreage sown to oats occurred on the farms in the seven municipalities, the average for all farms being ten percent of the cropland. The other crops are of less importance, only six percent of the farms visited had legumes and crops for forage other than the cereals. For all farms, the amount fallowed amounted to 35 percent of the total cropland, and that allowed to remain idle accounted for more than ten percent. The largest amount improved of land remaining idle was in the two townships of Pinto Creek, which averaged 155 acres per farm, or more than 30 per cent of the cropland.

The use of all land and cropland by percentages averaged by municipalities for 836 farms appears in Table 2.

TABLE 2.—USE OF THE LAND ON FARMS, AND OF CROPLAND, BY PERCENTAGES—AVERAGED BY MUNICIPALITIES—FOR 836 FARMS, ECONOMIC SURVEY, SOUTHWEST CENTRAL SASKATCHEWAN 1935

	All municipalities	Waverley No. 44	Wood River No. 74	Pinto Creek No. 75[1]	Gravelbourg No. 104	Glen Bain No. 105	Shamrock No. 134	Chaplin No. 164
Number of farms	836	143	152	21	146	138	122	114
PERCENTAGE OF TOTAL FARM AREA								
Cropland, including fallow and breaking	79.1	69.4	89.1	78.5	88.3	88.0	77.4	57.1
Unimproved and farmstead	20.9	30.6	10.9	21.5	11.7	12.0	22.6	42.9
PERCENTAGE OF CROPLAND								
Cropland, including fallow and breaking	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Wheat	41.0	34.7	43.9	27.8	47.9	43.9	39.4	31.6
Oats	10.0	9.8	9.6	9.0	8.7	8.3	11.2	13.6
Rye	1.9	1.5	0.2	3.6	0.4	0.2	3.3	9.3
Barley	0.7	0.6	0.2	0.8	0.6	0.8	0.2	2.2
Flax	0.2	—	0.2	—	—	0.2	—	—
Forage crops	0.2	0.3	—	0.2	0.2	0.2	0.8	0.6
Other crops	0.2	0.3	—	0.2	—	—	0.2	0.3
Fallow and breaking	35.4	35.3	39.9	26.9	38.1	38.0	30.6	26.3
Idle improved	10.4	17.5	6.0	31.5	4.1	8.4	14.3	16.1

[1] Two townships only (Tps. 7 and 8, rge. 7, W. 3rd mer.)

Use of Land Classified by Topography and Soil.—In general, the percentage of cropland per farm decreases as the topography becomes more rolling. The percentage of cropland also decreases as the soils become lighter, which means that the proportion of cropland seeded to wheat decreases as the land becomes more rolling, and as the soils become lighter. For farms with the topography level to undulating, four percent of the cropland on the clays and clay loams was idle, but this proportion increased to 20 percent of the cropland on the light loams and fine sandy loam. While a small part of this improved land remaining idle was unused because of the inability of the operator to seed or fallow it, chiefly on account of lack of funds, the larger part was left idle because it was advisable to do so. During the long period of drought the wind had eroded the soils, removing the surface layer from considerable areas and depositing it very irregularly in other parts of the same field, or in adjoining fields, which, while not affected themselves by erosion nevertheless were damaged by the piling drift. More particularly was this found to be true on the lighter soils.

The percentages of the total farm area in cropland, and the use of cropland by percentages, averaged for the 836 farms included in survey according to topography and soil appear in Table 3.

TABLE 3.—PROPORTION OF THE TOTAL AREA IN CROPLAND, AND THE PROPORTION OF THE CROPLAND USED BY THE IMPORTANT CROPS ON FARMS GROUPED ACCORDING TO TOPOGRAPHY AND SOIL, 836 FARMS, ECONOMIC SURVEY, SOUTHWEST CENTRAL SASKATCHEWAN 1935

	Level to undulating			Gently to moderately rolling			Strongly rolling to steep		
	Clays and clay loams	Silt loams and loams	Light loams and fine sandy loam	Clays and clay loams	Silt loams and loams	Light loams and fine sandy loam	Clay loams	Silt loams and loams	Light loams and fine sandy loam
Number of farms	148	74	68	155	145	139	33	42	32
Total acres pre farm	586	560	503	526	538	550	475	537	520
Acres of cropland per farm	526	488	374	461	429	398	293	246	319
PERCENTAGE OF FARM AREA									
Percent of total farm area in cropland	90	87	74	88	80	72	62	46	61
PERCENTAGE OF CROPLAND									
Cropland, including fallow and breaking	100	100	100	100	100	100	100	100	100
Wheat	47	45	35	45	42	30	41	41	36
Oats	9	9	11	9	11	10	11	16	11
Rye	—	—	6	—	1	7	4	2	2
Forage crops	—	—	—	—	—	1	1	—	—
Other crops[1]	1	—	1	1	—	1	1	3	1
Summer fallow	39	36	27	41	35	27	33	34	34
Idle improved	4	10	20	4	11	24	9	4	16

[1] Includes barley, flax and other crops not listed.

Changes in the Use of Land.—Little settlement in this area was reported previous to 1910, and before that time the land was used for ranching. During the five years following, the area was rapidly settled. and by 1916 over one million acres had been included in the occupied farms in the seven municipalities, of which more than one-half was improved. The amount of land occupied increased by about 12 percent from 1916 to 1921, but showed little change during the next five years. In 1931, however, the amount of land occupied was 25 percent greater than that reported in the Census of 1916.

TABLE 4.—TOTAL LAND OCCUPIED AND IMPROVED WITHIN THE MUNICIPALITIES OF WAVERLEY NO. 44, WOOD RIVER NO. 74, PINTO CREEK NO. 75, GRAVELBOURG NO. 104, GLEN BAIN NO. 105, SHAMROCK NO. 134 AND CHAPLIN NO. 164, BY CENSUS YEARS[1]

Census year	Total land occupied	Total land improved	Percentage improved of occupied
	Acres	Acres	p.c.
1916	1,039,361	571,627	55.0
1921	1,163,638	777,625	66.8
1926	1,166,030	857,637	73.6
1931	1,295,927	1,010,244	78.0

[1] Data from Census of Canada, 1916, 1921, 1926 and 1931.

The percentage of occupied land which had been improved increased steadily from 1916 to 1931. In 1916, 55 percent of the land occupied was improved compared with 67 percent in 1921, 74 percent in 1926 and 78 percent in 1931. (See Table 4). The economic survey of the seven municipalities in 1935 indicates that very little change had taken place since 1931 in the proportion of occupied land which had been improved. (See Table 2.)

During this period of occupancy and improvement (1916 to 1931) the proportion of total crop acreage of the seven municipalities which was used for wheat increased from 70 to 78 percent, while that in oats decreased from 19 to 15 percent.[4] Oats are not as well adapted to the semi-arid conditions of the area as wheat, and the tendency has been to grow less than formerly.

In 1916, flax occupied 8.6 percent of the total acreage in crop for the seven municipalities. Each succeeding census record shows a reduced acreage of flax and in 1931 this had fallen to less than one percent of the total acres in crop. In the earlier years, flax was frequently planted on land immediately after breaking in the spring to get a cash crop as quickly as possible, and this possibly accounts for part of the larger proportion grown when settlement was in progress. Reduction of acreage has resulted from a number of influences which include wide variations in yields and prices, difficulties of controlling weeds, of handling the crop after maturity and perhaps in some cases flax wilt. Only 13 of the 836 farms of the survey reported using any land for flax in 1934.

The Census report indicated a slight increase in the proportion of the total crop acreage used for barley from 1926 to 1931, but the proportion is very small, being only 1.9 percent in 1931. The survey indicates that less than one-half of this proportion was used for barley in 1935. Legumes and grasses were grown to some extent in 1926, but the acreage was less than one-fourth of one percent of the total crop acres in the seven municipalities. In 1931, this amount had fallen to less than one-half of what it was in 1926, but the survey indicates it was slightly more in 1935.

Table 5 presents a summary of the total acres in crops, and the percentage used for the various crops grown in the municipalities included in the economic survey of 1935 by Census years.

TABLE 5.—TOTAL ACRES IN CROPS, AND THE PERCENTAGE USED FOR VARIOUS CROPS GROWN IN THE MUNICIPALITIES OF WAVERLEY NO. 44, WOOD RIVER NO. 74, PINTO CREEK NO. 75, GRAVELBOURG, NO. 104, GLEN BAIN NO. 105, SHAMROCK, NO. 134 AND CHAPLIN NO. 164[1]

Census year	Total acres in crop	Wheat	Oats	Rye	Barley	Flax	Legumes and grasses	Other
	Acres	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
1916	414,026	70.4	18 8	0.2	0.6	8 6	–	1.4
1921	514,432	72.9	20.1	0.9	0.9	4.2	–	0.9
1926	560,901	77.4	17.3	0.6	0.8	1.8	0.2	1.9
1931	602,480	78.5	14.9	3.2	1.9	0.8	0.1	0.6

[1] Reports of the Census of Canada 1916, 1921, 1926 and 1931.

The growing of rye has increased markedly in the municipality of Chaplin, and to a less extent in the municipality of Shamrock. For Chaplin the Census reports indicate a consistent increase in the proportion which the acreage of rye bore to the total crop acreage from less than one percent in 1916, to more than 24 percent in 1931. The increase in the proportion of the crop acreage used for rye from 1926 to 1931 was accompanied by a reduction in the proportion used for wheat from 65 to 52 percent

[4] "Acreage in crops" differs from "acres of cropland" used frequently throughout this report, the former does not include fallow, breaking and idle improved.

for Chaplin. A less marked reduction occurred in the proportion of crop acreage used for wheat in the municipality of Shamrock, accompanied by an increase in the proportion used for rye. The survey indicates that for 1935 a somewhat smaller proportion of the total crop acreage of Chaplin was in rye than was reported for 1931 (16 percent of the acres in crops) and a larger proportion for Shamrock, (approximately six percent). Rye is grown on the lighter soils. Approximately 40 per cent of the land surface of the municipality of Chaplin, and 14 per cent of the municipality of Shamrock is mapped as fine sandy loam soil.

The Growing of Fall Rye.—Fall rye provides a vegetative cover for the soil in the early spring and thus helps to prevent the soil from drifting. Its use on the lighter soils began some years before the recent prolonged drought period which commenced in 1929. For the years 1924, 1927 and 1929, the returns per acre from fall rye were comparable to the returns per acre from wheat, and farmers were encouraged to grow fall rye. Under normal price conditions however, wheat is the more profitable and this acts as an incentive to grow this crop, even though problems with drifting soils might make it advisable to grow rye.

The relative attractiveness of wheat and fall rye is indicated in Table 6, which shows the yield, price and value per acre of fall rye and wheat for Crop District No. 3, from 1923 to 1934.

TABLE 6.—YIELD, FARM PRICE, AND VALUE PER ACRE OF FALL RYE AND WHEAT IN CROP DISTRICT NO. 3—1923 TO 1934[1]

Year	Yield per acre		Farm price per bushel		Value per acre	
	Fall rye	Wheat	Fall rye	Wheat	Fall rye	Wheat
	bus.	bus.	$	$	$	$
1934	1.0	3.6	0.46	0.59	0.46	2.14
1933	2.7	3.7	0.34	0.45	0.92	1.67
1932	6.6	7.7	0.24	0.35	1.58	2.69
1931	0.5	2.4	0.23	0.38	0.11	0.92
1930	7.2	8.0	0.17	0.47	1.23	3.75
1929	7.9	6.8	0.82	1.03	6.47	6.98
1928	17.6	25.8	0.74	0.77	13.06	19.83
1927	19.7	14.6	0.79	0.97	15.56	14.12
1926	15.1	15.8	0.74	1.08	11.16	17.01
1925	15.4	17.7	0.72	1.25	11.08	22.14
1924	16.4	13.9	0.95	1.21	15.54	16.84
1923	16.2	19.5	0.45	0.65	7.32	12.70
1923–1934	8.7	11.5	0.51	0.86	4.40	9.89

[1] Annual Reports of Secretary of Statistics, Department of Agriculture, Regina, Sask.

In review it may be restated that in the area surveyed the proportion of cropland per farm decreases as the topography becomes more rolling and the proportion of land which was at one time cultivated but is now allowed to remain idle, increases as the soils become lighter. Very little change has taken place since 1931 in the proportion of the land which has been improved. Since early settlement wheat has been the principal crop. An increased percentage of the crop acreage seeded to wheat is reported for each succeeding Census year 1916 to 1931. While other crops are grown such as oats, rye, barley, flax and forage crops, these have been of small importance compared with wheat. On the lighter soils there was an increase in the acreage of rye from 1926 to 1931, but a decrease occurred following that period probably due largely to the relatively lower returns ordinarily obtained from rye in comparison with wheat.

CHARGE ACCOUNT RECORDS OF PURCHASES OF CHEESE BY 92 FAMILIES IN THE CITIES OF OSHAWA AND MONTREAL

W. C. Hopper[1]

In the survey conducted in Oshawa, Ontario, and in Quebec City, by the Economics Branch during 1935 to obtain facts with respect to the utilization of cheese of different kinds by families of different sizes, different national origins and different family incomes, housewives who were interviewed were asked to state the quantity of various kinds of cheese purchased during the previous year. In almost all cases the figures given were estimates of these housewives. The results of this survey which cover 816 families in Oshawa and 790 in Quebec City will shortly be published in the Economic Annalist.

Another method of obtaining knowledge of the quantities of cheese consumed in homes would be to examine the records of purchases of cheese from retail stores on charge accounts. In the case of the latter method, it would be assumed that the families whose accounts are used, purchase all of the cheese used in their homes in the store from which the records are obtained.

In order to compare the results of the survey made in Oshawa and in Quebec City, in which the majority of the figures on the consumption of cheese were estimates, with actual sales as shown by charge accounts, the purchases of cheese of all kinds as shown by representative family accounts of retail stores were recorded and tabulated. In Oshawa, one independent store supplied such data for 50 families. No information on charge account purchases of cheese could be obtained for a sufficiently long period from retail stores in Quebec City but purchases of 42 French Canadian families on charge accounts from retail stores in Montreal were obtained.

The average per capita consumption of 150 individuals in 50 Oshawa families was 6.9 pounds of all types of cheese (Table 1). In Montreal, the average per capita consumption of 214 individuals in 42 families was 5.6 pounds of all types of cheese.

Although the proprietors of the stores stated that they believed the families selected purchased all of their cheese requirements in their stores, it is quite conceivable that as cheese is sometimes used as a special offering by stores which sell only for cash, some of these families might have purchased some cheese in other stores during the year. If any cheese were purchased outside of the charge account stores, the per capita consumption would, of course, be enlarged accordingly. It is unlikely, however, that the figures would be appreciably increased on this account.

In all Canadian cities a considerable number of the families belong to low income groups, but as the majority of the families whose charge accounts were examined had medium or high incomes, the average per capita and per family consumption of the 92 families does not accurately reflect the average consumption of cheese for the entire cities of Oshawa and Montreal.

Table 1.—Purchases of cheese of all kinds on charge accounts by 92 families from independent retail stores in Oshawa and Montreal, 1935

City	Number of families	Average Number of individuals in family	Annual consumption per family	Annual per capita consumption
Oshawa	50	3.0	20.7	6.9
Montreal	42	5.1	28.6	5.6
Total or average	92	4.0	24.3	6.1

When the total sales of all cheese to the 50 Oshawa families were combined and sorted by monthly sales, the quantity sold from month to month was remarkably

[1] Chief, Division of Marketing, Economics Branch, Department of Agriculture, Ottawa.

uniform (Table 2). The sales to the 50 families were largest in the months of July, September and December, the smallest in January and October.

TABLE 2.—SEASONAL DISTRIBUTION OF PURCHASES OF 1036 POUNDS OF CHEESE OF ALL KINDS BY 50 FAMILIES FROM ONE INDEPENDENT RETAIL STORE IN OSHAWA, ONTARIO—NOVEMBER 1ST, 1934, TO NOVEMBER 1ST, 1935

Percentage purchased in various months

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
%	%	%	%	%	%	%	%	%	%	%	%	%
7.7	8.0	8.5	8.3	8.4	8.0	8.9	8.5	8.9	7.5	8.5	8.8	100

If the sample of the charge accounts had been larger than 92, it is quite possible that the results might have been somewhat different, but it is unlikely that the differences for the stores selected would be very significant as the accounts were taken at random as an average of all the accounts of the stores. Examination of charge accounts in other retail stores in Oshawa and Montreal might, however, give results which would be materially different.

FINANCIAL RESULTS OF TWO YEARS' FARM OPERATIONS IN NEW BRUNSWICK

IAN S. MCARTHUR[1]

During the summer of 1936 a farm questionnaire was sent to the 199 farmers in Carleton and Victoria counties of New Brunswick who had co-operated with the Economics Branch during the summer of 1935 in a farm management survey. A short visit was also made to the area during the past summer and a total of 70 records were secured covering the farm business for the crop year of 1935–36. The crop year 1935–36 was a substantially better one for these New Brunswick farmers, due chiefly to the improved market for potatoes, the main cash crop of the district. During the previous year the price of potatoes was extremely low, averaging only 24 cents per barrel of 165 pounds and during that season only 51.4 per cent of the potato crop found a market. During the season of 1935–36 the average price received by the farmers included in the study was $1.35 per barrel and 77.9 per cent of the crop was marketed. The yield per acre was somewhat lower in 1935, averaging 95.8 barrels per acre compared with the very high average of 130 barrels per acre in 1934.

Utilization of Crop Land.—The low prices received for the 1934 potato crop, coupled with a shortage of cash to buy commercial fertilizer in the spring of 1935, led to a reduction in potato acreage averaging 4.3 acres per farm, or a reduction of 33 per cent from the average of 13.1 acres grown in 1934. Acreages of other crops did not show any material change. There was a total reduction of 5.2 acres per farm devoted to field crops and hay. In the case of hay the 1935 crop was somewhat heavier than in 1934 and the total tonnage cut was greater in the second year, despite the reduction in the acreage cut for hay. The land which was not used for field crops or hay in 1935 apparently reverted to pasture.

TABLE 1.—UTILIZATION OF CROP LAND PER FARM ON 70 FARMS, CARLETON AND VICTORIA COUNTIES, NEW BRUNSWICK, 1934–35 AND 1935–36 CROP YEARS

Crop	Acres 1934–35	Acres 1935–36	Change Acres
Oats	25.0	25.6	+ 0.6
Barley	1.9	2.2	+ 0.3
Wheat	2.2	2.1	− 0.1
Buckwheat	1.5	1.4	− 0.1
Hay	40.9	39.3	− 1.6
Potatoes	13.1	8.8	− 4.3
Miscellaneous	0.9	0.9	—
Total	85.5	80.3	− 5.2

[1] Graduate Assistant, Economics Branch, Department of Agriculture, Ottawa, Canada.

Farm Expenses.—Farm expenses were materially reduced during the 1935–36 crop year, due almost entirely to the reduction in the acreage of potatoes. There was a reduction of $195 per farm in current farm expenses, of which $93 was on account of the reduced use of commercial fertilizer and $62 was on account of the reduced use and much lower price of seed potatoes. Further reductions were also effected in the case of capital expenditures, amounting to $44 per farm for new buildings and machinery, and a reduction of $36 per farm for the purchase of livestock. The total reduction in all farm expenses amounted to $278 per farm.

In the data covering the 1935–36 crop year certain minor items of farm expense were grouped together and entered at the same figure as for the previous year. While these expenses totalled to an average of $305 per farm, the individual items were relatively small. Items included under this heading included use of auto and truck $65 per farm; insurance on buildings $29 per farm; horseshoeing $23 per farm; fertilizer other than for potatoes $27 per farm and feeds and supplies $36 per farm. While the assumption that these costs would remain constant may not be entirely true, it is probable that the variation would not be sufficiently great to make any material difference to the results of the study.

TABLE 2.—EXPENSES PER FARM, 70 FARMS, CARLETON AND VICTORIA COUNTIES, NEW BRUNSWICK, 1934–35 AND 1935–36 CROP YEARS

Item	1934–35 $	1935–36 $	Change $
Hired labour	165	166	+ 1
Unpaid labour	168	165	− 3
Board of labour	55	58	+ 3
Municipal taxes	25	26	+ 1
School taxes	29	28	− 1
Fertilizer	271	178	− 93
Lime	3	3	—
Copper sulphate	21	12	− 9
Arsenate	8	4	− 4
Potato barrels	12	8	− 4
Machinery Repairs	34	26	− 8
Potato Seed	90	28	− 62
Potato storage	19	3	− 16
Miscellaneous	305	305	—
Total current	1,205	1,010	−195
New buildings and equipment	72	28	− 44
Livestock purchases	110	74	− 36
Inventory decrease	220	217	− 3
Total all expenses	1,607	1,329	−278

Farm Receipts.—Farm receipts for the crop year 1935–36 amounted to $1,501 per farm or an increase of $541 per farm over the previous year. The increase in receipts from potatoes alone amounted to $679 per farm, but this gain was offset to some extent by reduced income from the sale of other crops and livestock. Also there was a reduced increase in farm inventory during the second year studied. The sale of livestock products, chiefly butter and eggs was $24 per farm greater in 1935–36, due chiefly to somewhat improved prices for these products. In the 1934–35 crop year potatoes provided only 23 per cent of the total farm receipts, while in 1935–36 this crop accounted for 60 per cent of the total receipts.

TABLE 3.—RECEIPTS PER FARM, 70 FARMS, CARLETON AND VICTORIA COUNTIES, NEW BRUNSWICK, 1934–35 AND 1935–36 CROP YEARS

Source	1934–35 $	1935–36 $	Change $
Potatoes	220	899	+ 679
Other crops	222	153	− 69
Livestock sales	198	172	− 26
Livestock products	97	121	+ 24
Miscellaneous	84	82	− 2
Inventory increase	139	74	− 65
Total	960	1,501	+ 541

Financial Summary.—With total expenses reduced by $278 per farm and total receipts increased by $541 per

farm, there was a net improvement in the financial results of the year's farm operations amounting to $819 per farm. Farm income which averaged a loss of $647 per farm for the 1934–35 crop year, showed a surplus of $172 per farm for 1935–36. Farm perquisites, consisting of the value of farm products consumed on the farm and an allowance for the use of the farm home, were considered to be essentially the same for the two years. Interest on average capital was also taken at the 1934–35 figure to secure a figure for operators income which resulted in a loss of $614 per farm in 1934–35 and a gain of $205 per farm for 1935–36.

TABLE 4.—FINANCIAL SUMMARY PER FARM, 70 FARMS, CARLETON AND VICTORIA COUNTIES, NEW BRUNSWICK, 1934–35 AND 1935–36 CROP YEARS

	1934–35 $	1935–36 $	Change $
Cash receipts	821	1,427	+ 606
Inventory increase	139	74	− 65
Total	960	1,501	+ 541
Total expenses	1,607	1,329	− 278
Farm income	−647	172	+ 819
Farm perquisites	415	415	—
Less interest on Capital 5%	382	382	—
Operator's income	−614	205	+ 819

THE CURRENT AMERICAN FARM PROGRAM

A glance at the current farm program in the United States may be of interest in view of the discussions now being held in that country with respect to future policy. By its decision in the Hoosac Mills case last January the Supreme Court invalidated that part of the Agricultural Adjustment Act which provided for production control as carried out through contracts with individual farmers and financed by processing taxes. This decision received such wide publicity that many people have assumed its effect on the farm program to be just as dire as was that of the Schecter case, invalidating the NIRA, on the Administration's plan for industry. This is hardly true. There is more to the AAA than production control and there is more to the "New Deal" farm policy than the AAA. Moreover, it may be that the soil conservation plan which has succeeded the AAA production control measures can accomplish the same ends, although, lacking the processing taxes, it cannot be termed "self liquidating".

The program for farm aid has three main divisions. In addition to the Agricultural Adjustment Administration there are the Farm Credit Administration and the Resettlement Administration.

The Farm Credit Administration and the institutions operating under its supervision provide a co-ordinated credit system for agriculture. Loans are made direct to individual farmers, and also to co-operatives and rural credit associations. Through these various channels the farmer may secure a loan to meet almost any purpose—production expenses, building or equipment costs, or re-financing. From May 1, 1933, to the end of 1935, over a million loans were made and the total amount of such loans exceeded $3,000,000,000.

The Resettlement Administration, through its various branches, endeavours primarily to aid the farmer on marginal and drought stricken lands. The Resettlement program includes land improvement, land retirement and the transfer of families, loans to those who cannot get credit elsewhere, farmer-creditor debt adjustments, grants and housing projects. In many of its phases it is virtually a part of the Government's relief activities.

The Agricultural Adjustment Administration carries out the provisions of various Acts of Congress designed primarily to raise farm incomes. Chief among the means

adopted towards this end are: marketing agreements, purchase of surplus commodities and, most important, payments to farmers for soil conservation efforts.

Under the marketing agreement provisions of the Agricultural Adjustment Act—a portion of the Act which has not lost its constitutionality—producers are enabled to practise unified marketing. A large proportion of the fruits and vegetables entering interstate trade are now under regulation, and there are also a number of agreements relating to milk and other products. As some of the agreements are now completing their fourth year of operation it must be assumed that they have proved beneficial to the producers.

The program for removing price-depressing surplus agricultural products from normal channels of trade is largely financed under an amendment to the Agricultural Adjustment Act. This makes available to the Secretary of Agriculture an amount equivalent to 30 percent of the annual customs receipts for uses which include encouraging domestic consumption and developing new markets and new uses for farm products. Purchase and distribution of a wide range of commodities have been made. The distribution has largely been to relief agencies—2,500,000,000 pounds of farm products have thus been disposed of—but the program has also included such diverse activities as subsidizing the export of pears and supplying cotton to various States for experimental use in road building.

By far the most important activity of the Agricultural Adjustment Administration is the national soil conservation program. This program, provided for by the Soil Conservation and Domestic Allotment Act, is the successor to the production control features of the Agricultural Adjustment Act. It provides for payments to producers who divert a part of their production from "soil-depleting" to "soil-conserving" crops or uses. Its dual intent is to maintain soil fertility and to discourage over-production of the crops which tended to accumulate in surpluses. $470,000,000 was the amount made available for this work in 1936. For administration purposes the nation was divided into five regions; within each region State committees and, finally, county committees are appointed to handle the details. It is left to each farmer to make application for the payments to which he is entitled. There are two types of payment: Class I represents compensation for loss of return on the crop area diverted from "soil-depleting" crops; Class II represents a contribution towards the cost of growing soil conserving and soil building crops or the carrying out of fertilizing, terracing, tree planting and other measures for soil improvement.

A farmer who qualifies for a Class I payment by diverting his acreage to soil conserving crops will naturally qualify for the Class II payment as well. A farmer who does not reduce his soil depleting acreage but who does engage in soil building practices will be eligible for the Class II payment only. All payments are made on an acreage basis except the Class I payments for some special crops, notably cotton, tobacco and peanuts, where the compensation is based on the amount of the commodity which might have been produced on the land diverted to soil conserving uses. While the rate of payment varies with conditions, the general average for Class I payments is to be $10 per acre; the Class II payments are limited to a maximum of $1 per acre for each farm. Soil depleting crops include corn, cotton, tobacco, wheat, oats, barley, truck and canning crops, sugar cane and others. Soil conserving crops consist mainly of the legumes and perennial grasses, and forest trees planted on crop land.

No estimates have as yet come to hand as to the extent to which farmers have availed themselves of the provisions of the Act, or the probable expenditures to be made under it. The widespread drought of last summer was in itself an excellent check on whatever potential overproduction there may have been. Whether or not the plan will receive a further trial in 1937 is another matter which remains in doubt at the moment, for various changes in the farm program are just now being considered by the Administration.

PROVINCIAL FARM CREDIT SYSTEM IN QUEBEC

The Quebec Parliament has recently enacted legislation to establish a provincial farm credit system to aid already established farmers or any person acquiring for cultivation one or more farms forming one enterprise, by means of loans granted by an agency called, "Quebec Farm Credit Bureau" which will have powers to borrow under the Government guarantee up to $10,000,000.

Long term loans will be granted to farmers on the security of a first mortgage on farms up to 65 per cent of the appraised value by the Bureau. Borrowers will also be able to secure additional loans on the security of a second mortgage for a shorter period and in these cases aggregate loans are not to exceed 75 per cent of the appraised value of the farm. Loans, however, will never exceed $6,000 to each borrower. When the borrower's debts exceed 65 per cent of the appraised value of the farm given as security the amount of the loan may be increased up to 75 per cent of the value of the farm provided that creditors agree to accept this amount as final settlement of their claim with the debtor and give him a clearance to this effect.

The rate of interest on loans to farmers is 2½ per cent per annum payable semi-annually. Repayment of principal is made under an amortization plan at the rate of 1½ per cent for a period of thirty-nine years and a half or at the option of the borrower for thirty years with the outstanding balance of the principal to be repaid at the end of this period.

ECONOMIC LITERATURE

UNEMPLOYMENT. An International Problem. A report by a Study Group of Members of the Royal Institute of International Affairs. Oxford University Press, London: Humphrey Milford. 1935. 442 pages and Appendices and Index.

This exhaustive study of world unemployment is prepared by a group of members under the Chairmanship of the Viscount Astor, and is issued under the auspices of the Royal Institute of International Affairs. World-wide in scope, it presents the problems confronting practically every country at the present time. While it is pointed out that each country has problems almost entirely peculiar to itself, yet mere national thought and action can do little but act as a palliative to the general world unemployment situation. Unemployment may be described as "one aspect of the disorganization of the structure of primary production, industry and the exchange of commodities, and the social and political system". This being the case, it is submitted that the problem of the 30 million of unemployed throughout the world becomes a collective one, and should be recognized as such. "On the political side there is tardy and partial recognition that avoidance of armed conflict is a question of collective action by the nations. The conception of collective security must be applied to economic problems".

The social consequences of unemployment are presented in the early pages of the volume in the general descriptive section; loss of wealth and efficiency, the absence of apprentices and learners in skilled and semi-skilled trades, the effect of continued unemployment on young persons and the possibility of its detrimental results upon the health and well-being of the community. Employment in Great Britain, Germany, France, the United States and the U.S.S.R. is analyzed in considerable detail, and the scope of the unemployment schemes of insurance in the first two countries receives special comment.

The second section—The General Background—is devoted to the post-war period and the depression of 1929–34 and its effect upon employment. The changes in the economic structure are fully covered and include chapters on the problems confronting specified industries; the effect of trusts and cartels, protective policies and technological developments. The major agricultural countries are reported upon quite extensively. The population factor receives considerable attention, and

the slackening of population in Great Britain and certain European countries is mentioned as being of particular significance to agricultural countries with markets in Great Britain and Europe. It is pointed out that European agrarian policies have only helped to limit still further, the market for agricultural products from abroad.

Remedial measures are covered by the third section of the book and include policies which may be exercised by the State, such as public works, general relief work and employment on the land. In a sub-section consideration is given to the possibility of the organization of the labour market to absorb some of the surplus by a more efficient control of the supply of labour and by a more effective method of the spreading of the work. The argument in favour of shorter hours is discussed and attention is paid to the possibility of vocational guidance as a means of better distribution of workers throughout the trades and professions. A further section deals with unemployment insurance and relief, and social services for the unemployed. It is of interest to note that eight countries have compulsory unemployment insurance, and two have insurance of a semi-compulsory nature. Of the 38 million persons covered by compulsory insurance, about 31 millions are accounted for by the British and German systems. Voluntary schemes of insurance in ten different countries cover approximately 4 millions.

Sixteen pages are devoted to the Summary and the following extract presents both accurately and tersely, the problem facing the statesman of to-day: "Generally speaking, the first requisite in framing a long-term employment policy is to know whether the scales are to come down on the side of resumption of political co-operation or on that of growing isolation. If there is to be permanent political co-operation there must be economic agreement, since no political co-operation is stable where economic conflict is recurrent."

A vast amount of study and research has been accomplished in compiling this book, and acknowledgment is made to the authorities in many countries who rendered valuable assistance and supplied critical commentary. The bibliography, referred to in foot-notes, is immense. Seventeen appendices and an adequate index add to the value of this comprehensive volume, which will no doubt become a standard reference in its particular sphere.

A report on the distribution of national income compiled by the United States Department of Commerce shows that in 1935, 67.3 percent of the total income of all people of that country was in the form of wages and salaries. Unincorporated business, including farming, amounted to 16.2 percent and the remaining 16.5 percent represented income from dividends, interest receipts, rents and other property income.

Some idea of the magnitude of the English Milk Marketing Scheme is gathered from the yearly turnover which is 389 million dollars. The Milk Board deals in England and Wales with 90,000 milk producers and 70,000 producer-retailers who have a combined gallonage of about one thousand million gallons. The Board's daily post-bag averages 1,600 letters, but at the peak time of monthly returns from the farmers 25,000 may be received in a single day. With the aid of accounting machines, the farmers' pay-sheets are made up at the rate of 2,000 an hour.

Exports of Canadian products in October totalled $110,993,509 and imports during the month were $65,187,974. October exports exceeded those of any month since November 1929 and were $20,500,000 ahead of the total for October 1935.